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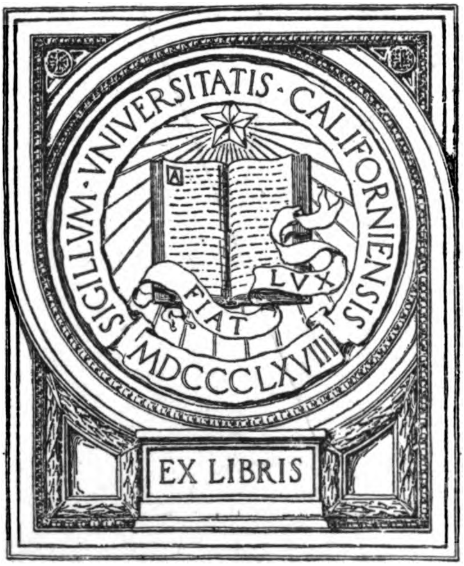
Bulletin

Maine Agricultural Experiment Station

EXCHANGE



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TWENTY-NINTH ANNUAL REPORT

OF THE

Maine Agricultural Experiment Station

ORONO, MAINE

1913

STATE OF MAINE.

1914

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AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE

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Organization January to June, 1913.

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WILLIAM H. DAVIS, Augusta,	*Maine Livestock Breeders' Association*
WILLIAM G. HUNTON, Readfield,	*Maine Seed Improvement Association*

AND THE HEADS AND ASSOCIATES OF STATION DEPARTMENTS.

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	GEM M. COOMBS,	*Stenographer*
	JANIE LOGIE FAYLE,	*Stenographer*
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	CLARENCE W. BARBER, B. S.,	*Assistant*
	WALTER ANDERSON,	*Poultryman*
	ESTELLA MORRISON,	*Computer*
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	HERMAN H. HANSON, M. S.,	*Associate*
	EDWARD E. SAWYER, B. S.,	*Assistant*
	HELEN W. AVERILL, B. S.,	*Assistant*
	ELMER R. TOBEY, B. S.,	*Assistant*
	HARRY C. ALEXANDER,	*Laboratory Assistant*
ENTOMOLOGY	ALICE W. AVERILL,	*Laboratory Assistant*
	EDITH M. PATCH, PH. D.,	*Entomologist*
PLANT PATHOLOGY	WARNER J. MORSE, PH. D.,	*Pathologist*
	CHARLES E. LEWIS, PH. D.,	*Associate*
	MICHAEL SHAPOVALOV, B. A.,	*Assistant*
	VERNON FOLSOM,	*Laboratory Assistant*
HIGHMOOR FARM	WELLINGTON SINCLAIR,	*Superintendent*
	GEORGE A. YEATON,	*Orchardist*
	ROYDEN L. HAMMOND,	*Seed Analyst and Photographer*
	CHARLES S. INMAN,	*Assistant*

MAINE
AGRICULTURAL EXPERIMENT STATION
ORONO, MAINE

Organization July to December, 1913.

THE STATION COUNCIL.

PRESIDENT ROBERT J. ALEY,	*President*
DIRECTOR CHARLES D. WOODS,	*Secretary*
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WILLIAM G. HUNTON, Readfield,	*Maine Seed Improvement Association*

AND THE HEADS AND ASSOCIATES OF STATION DEPARTMENTS, AND THE DEAN OF THE COLLEGE OF AGRICULTURE.

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	GEM M. COOMBS,	*Stenographer*
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CHEMISTRY	JAMES M. BARTLETT, M. S.,	*Chemist*
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	MICHAEL SHAPOVALOV, M. S.,	*Assistant*
	VERNON FOLSOM,	*Laboratory Assistant*
HIGHMOOR FARM	WELLINGTON SINCLAIR,	*Superintendent*
	HAROLD G. GULLIVER,	*Scientific Aid*
	ROYDEN L. HAMMOND,	*Seed Analyst and Photographer*
	CHARLES S. INMAN,	*Assistant*

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The publications of this Station will be sent free to any address in Maine. All requests should be sent to

Agricultural Experiment Station,
Orono, Maine.

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ANNOUNCEMENTS.

Establishment of the Station.

The Maine Fertilizer Control and Agricultural Experiment Station, established by Act of the Legislature approved March 3, 1885, began its work in April of that year in quarters furnished by the College. After the Station had existed for two years, Congress passed what is known as the Hatch Act, establishing agricultural experiment stations in every state. This grant was accepted by the Maine Legislature by an Act approved March 16, 1887, which established the Maine Agricultural Experiment Station as a department of the University. The reorganization was effected in June, 1887, but work was not begun until February 16, 1888. In 1906 Congress passed the Adams Act for the further endowment of the stations established under the Hatch Act.

The purpose of the experiment stations is defined in the Act of Congress establishing them as follows:

"It shall be the object and duty of said experiment stations to conduct original researches or verify experiments on the physiology of plants and animals; the diseases to which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth; the comparative advantage of rotative cropping as pursued under a varying series of crops; the capacity of new plants or trees for acclimation; the analysis of soils and water; the chemical composition of manures, natural and artificial, with experiments designed to test their comparative effects on crops of different kinds; the adaptation and value of grasses and forage plants; the composition and digestibility of the different kinds of food for domestic animals; the scientific and economic questions involved in the production of butter and cheese; and such other researches or experiments bearing directly on the agricultural industry of the United States as may in each case be deemed advisable, having due regard to the varying conditions and needs of the respective states or territories."

The work that the Experiment Station can undertake from the Adams Act fund is more restricted and can "be applied only to paying the necessary expenses of conducting original researches or experiments bearing directly on the agricultural industry of the United States, having due regard to the varying conditions and needs of the respective states and territories."

INVESTIGATIONS.

The Station continues to restrict its work to a few important lines, believing that it is better for the agriculture of the State to study thoroughly a few problems than to spread over the whole field of agricultural science. It has continued to improve its facilities and segregate its work in such a way as to make it an effective agency for research in agriculture. Prominent among the lines of investigation are studies upon the food of man and animals, the diseases of plants and animals, breeding of plants and animals, orchard and field experiments, poultry investigations, and entomological research.

The Legislature of 1913 provided for investigations by the Station in animal husbandry which make Chapter 141 of the Public Laws for 1913. The following quoted from the act outlines the purpose of the act: "The Maine Agricultural Experiment Station in addition to the investigations now conducted by it, shall conduct scientific investigations in animal husbandry, including experiments and observations on dairy cattle and other domestic animals. Said investigations shall be carried out under control of the director of the Maine Agricultural Experiment Station. There shall be appropriated annually from the State Treasury the sum of five thousand dollars to be paid to the Maine Agricultural Experiment Station and the same shall be expended by the director of said Station in executing the provisions of this act."

INSPECTIONS.

Up to the close of the present year it has been the duty of the Director of the Station to execute the laws regulating the sale of agricultural seeds, apples, commercial feeding stuffs, commercial fertilizers, drugs, foods, fungicides and insecticides, and the testing of the graduated glassware used by creameries. Beginning with January 1914 the purely executive part of these laws will be handled by the Commissioner of Agriculture. The analytical examination of the samples and the publishing the results of the analyses will still be done by the Station. The cost of the inspections is borne by fees and by a state appropriation.

OFFICES AND LABORATORIES.

The offices, laboratories and poultry plant of the Maine Agricultural Experiment Station are at the University of Maine, Orono. Orono is the freight, express, post, telegraph and telephone address for the offices and laboratories.

Visitors to the Station will find it convenient to leave the steam cars at Bangor or Old Town, as the railway station at Orono is a mile from the University. Bangor and Old Town trolley cars pass through the campus. They pass the railway station in Bangor 5 minutes after the hour and half hour, and the railway station in Old Town, 20 minutes after and 10 minutes before the hour.

AROOSTOOK FARM.

The Legislature of 1913 (Chapter 190 of the Private Laws of 1913) named a committee and appropriated ten thousand dollars for the purpose of purchasing land for a farm for conducting scientific investigations in agriculture in Aroostook County. The law provides that: "The Maine Agricultural Experiment Station shall have the general supervision, management and control of said farm and of all experiments and investigations conducted thereon, and may if it sees fit or deems it best authorize any agent or agents of the United States Department of Agriculture to conduct experiments upon such farm under such terms as it deems best."

The committee on location decided that it would be impracticable to purchase a farm in Aroostook County for the amount named in the act. After several meetings and proposals made from several towns in the county it was decided to purchase a farm at Presque Isle which, with the buildings to be erected upon it will cost $23,000. The farm that was purchased contains about 275 acres, has upon it a large barn with concrete potato house in the basement, a small dwelling house for the farmer. The erection of a suitable dwelling house for the farm superintendent is provided for by money raised by the citizens of Presque Isle.

The Station came into possession of the farm late in December 1913, and work will be begun in the season of 1914.

HIGHMOOR FARM.

Highmoor Farm, purchased by the State for the use of the Station, is located in the town of Monmouth, 2 1-2 miles from the Monmouth station and the same distance from the Leeds Junction station. It is on the Farmington branch of the Maine Central Railroad. A flag station, called Highmoor, is on the farm. Monmouth is the post, telegraph and telephone address for Highmoor Farm. Both Leeds Junction and Monmouth are freight and express addresses.

THE AIM OF THE STATION.

Every citizen of Maine concerned in agriculture has the right to apply to the Station for any assistance that comes within its province. It is the wish of the Trustees and Station Council that the Station be as widely useful as its resources will permit.

In addition to its work of investigation, the Station is prepared to make chemical analyses of fertilizers, feeding stuffs, dairy products and other agricultural materials; to test seeds and creamery glassware; to identify grasses, weeds, injurious fungi and insects, etc.; and to give information on agricultural matters of interest and advantage to the citizens of the State.

All work proper to the Experiment Station and of public benefit will be done without charge. Work for the private use of individuals is charged for at the actual cost to the Station. The Station offers to do this work only as a matter of accommodation. Under no condition will the Station undertake analyses, the results of whch cannot be published, if they prove of general interest.

CORRESPONDENCE.

As far as practicable, letters are answered the day they are received. Letters sent to individual officers are liable to remain unanswered, in case the officer addressed is absent. All communications should, therefore, be addressed to the Director or to the

Agricultural Experiment Station,
Orono, Maine.

PUBLICATIONS.

The Station is organized so that the work of investigation is distinct from the work of inspection. The results of investigation are published in the bulletins of the Station. These make up the annual report for the year. The results of the work of inspection are printed in publications known as Official Inspections. These are paged independently of the bulletins and are bound in with the annual report as an appendix thereto. Miscellaneous publications consisting of newspaper notices of bulletins, newspaper bulletins and circulars which are not paged consecutively and for the most part are not included in the annual report are issued during the year.

All the bulletins issued by the Station are sent to the names upon the official mailing list prepared by the Office of Experiment Stations, to all newspapers in Maine and to libraries and to agricultural exchanges. Bulletins which have to do with general agriculture and the Official Inspections which bear upon the feeding stuffs, fertilizer and seed inspections are sent to a general mailing list composed chiefly of farmers within the State. The publications having to do with the food and drug inspection are sent to a special list including all dealers in Maine and other citizens who request them. The annual report is sent to directors of experiment stations and to libraries. Copies of all publications are sent to the newspapers within the State and to the press on the exchange list outside of the State.

BULLETINS ISSUED IN 1913.

No. 209. New Mineral Fertilizer. 12 pages.
No. 210. Spruce Bud Worm and Spruce Leaf Miners. 24 pages, 9 illustrations.
No. 211. Potato Flea Beetle. 20 pages, 8 illustrations.
No. 212. Orchard Spraying Experiments in 1912. 16 pages.
No. 213. Aphid Pests of Maine. II. Willow Family. 28 pages, 36 illustrations.
No. 214. The Biology of Poultry Keeping. 20 pages, 2 illustrations.
No. 215. The Measurement of the Intensity of Inbreeding. 16 pages.
No. 216. Poultry Notes, 1911-13. 28 pages, 8 illustrations.
No. 217. Woolly Aphid of the Apple. 20 pages, 19 illustrations.
No. 218. Tables for Calculating Coefficients of Inbreeding. 12 pages.
No. 219. Comparative Studies of Certain Disease Producing Species of Fusarium. 56 pages, 33 illustrations.

No. 220. Woolly Aphids of the Elm. 40 pages, 24 illustrations.
No. 221. Variations of Fat in Milk. Pedigree System Applied to Guinea-Pigs. Aluminum in Chick Feeds. 20 pages, 6 illustrations.
No. 222. Meteorology, Finances and index. 28 pages, 2 illustrations.

OFFICIAL INSPECTIONS ISSUED IN 1913.

No. 46. Seed Inspection. 12 pages.
No. 47. Fungicide and Insecticide Inspection, 1912. 16 pages.
No. 48. Drugs. 8 pages.
No. 49. Protection of Food Offered for Sale. 8 pages.
No. 50. Feeding Stuff Inspection. 40 pages.
No. 51. Weight of Butter. 16 pages.
No. 52. Seed Inspection. 12 pages.
No. 53. Fertilizer Inspection. 36 pages.
No. 54. Insecticide and Fungicide Inspection, 1913. 8 pages.
No. 55. Clams, Oysters and Scallops. 8 pages.

MISCELLANEOUS PUBLICATIONS ISSUED IN 1913.

No. 464. Fungicide and Insecticide Inspection, Manufacturer's Certificate. 1 page.
No. 465. Feeding Stuff Inspection, Manufacturer's certificate. 1 page.
No. 466. List of Registered Feeding Stuffs. 4 pages.
No. 467. Potato Flea Beetle. 8 pages.
No. 468. Preparation and Use of Lime-Sulphur in Orchard Spraying. 10 pages.
No. 469. Short Weight Butter. 1 page.
No. 470. Newspaper Notice Bulletin 207. 1 page.
No. 471. Methods of Poultry Management at the Maine Agricultural Experiment Station. 78 pages.
No. 472. Newspaper Notice Bulletin 210. 1 page.
No. 473. Newspaper Notice Circular 467. 1 page.
No. 474. Newspaper Notice Circular 468. 1 page.
No. 475. An Act to Provide for Scientific Investigations in Agriculture in Aroostook County. 4 pages.
No. 476. Newspaper Notice Bulletin 212. 1 page.
No. 477. Library Card. 1 page.
No. 478. Newspaper Notice Circular 471. 1 page.
No. 479. Map Highmoor Farm. 1 page.
No. 480. Experiments at Highmoor Farm, 1913. 8 pages.
No. 481. List of Papers from the Biological Laboratory, Vol. I, 8 pages.
No. 482. Aphid Galls of the Poplar. 8 pages.
No. 483. Aphids. 10 pages.
No. 484. Note Regarding the Calculation of Coefficients of Inbreeding. 1 page.

No. 485. Special Report of the Maine Agricultural Experiment Station for the Commissioner of Agriculture for the Year 1912. 48 pages.
No. 486. Blank Record Sheet. 1 page.
No. 487. Blank Record Sheet. 1 page.
No. 488. Summaries of Station Work No. 1. Apple Studies. 20 pages.
No. 489. Newspaper Notice Bulletin 216.
No. 490. Station Publications. 1 page.
No. 491. Available Bulletins and Reports of the Station. 4 pages.

BIOLOGY PUBLICATIONS 1913.

In the numbered series of "Papers from the Biological Laboratory:"

No. 42. Data on Sex Determination in Cattle. By Raymond Pearl and H. M. Parshley. Biol. Bull., Vol. 24, pp. 205-225.
No. 43. Note Regarding the Relation of Age to Fecundity. By Raymond Pearl. Science, N. S., Vol. 37, pp. 226-228.
No. 44. Genetics and Breeding. By Raymond Pearl. Science, N. S., Vol. 37, pp. 539-546.
No. 45. A Biometrical Study of Egg Production in the Domestic Fowl. III. Variation and Correlation in the Physical Characters of the Egg. By Raymond Pearl and Frank M. Surface. U. S. Dept. of Agr., Bureau of Animal Industry, Bull. 110, Pt. III. (In press).
No. 46. The Relative Time of Fertilization of the Ovum and the Sex Ratio in Man. By Raymond Pearl and Redcliffe N. Salaman. American Anthropologist. (In press).
No. 47. A Contribution Towards the Analysis of the Problem of Inbreeding. By Raymond Pearl. American Naturalist, Vol. XLVII, pp. 577-615.
No. 48. The Odd Chromosome in the Spermatogenesis of the Domestic Chicken. By Alice M. Boring and Raymond Pearl. Journ. of Exp., Zool., Vol. 16, pp. 53-83.
No. 49. The Biology of Poultry Keeping. By Raymond Pearl. Me. Agr. Exp. Sta. Ann. Rept. for 1913, pp. 101-120.
No. 50. A Biometrical Study of Egg Production in the Domestic Fowl. IV. Factors Inflencing the Size, Shape, and Physical Constitution of Eggs. By Maynie R. Curtis. (In press.
No. 51. Tables for Calculating Coefficients of Inbreeding. By Raymond Pearl and John Rice Miner. Me. Agr. Exp. Sta., Ann. Rept. for 1913, pp. 191-202.
No. 52. On the Correlation between the Number of Mammae of the Dam and Size of Litter of Mammals. I. Interracial Correlation. By Raymond Pearl. Proc. Soc. for Exp. Biol. and Med., Vol. XI., pp. 27-30.

No. 53. On the Correlation between the Number of Mammmae of the Dam and Size of Litter in Mammals. II. Intraracial Correlation in Swine. By Raymond Pearl. Proc. Soc. for Exp. Biol. and Med., Vol. XI., pp. 31-32.

No. 54. On the Results of Inbreeding a Mendelian Population: A Correction and Extension of Previous Conclusions. By Raymond Pearl. American Naturalist, Vol. XLVIII., pp. 57-62.

No. 55. Variation in the Tongue color of Jersey Cattle. By Raymond Pearl. Proc. Soc. for Promotion of Agricultural Science, 1913.

No. 56. Studies on the Physiology of Reproduction in the Domestic Fowl. VI. Double and Triple-Yolked Eggs. By Maynie R. Curtis. Biol. Bull. Vol. XXVI., pp. 55-83.

No. 57. Constants for Normal Variation in the Fat Content of Mixed Milk. By Raymond Pearl. Me. Agr. Exp. Sta., Ann. Rept. for 1913, pp. 299-305.

No. 58. A Pedigree System for Use in Breeding Guinea-Pigs and Rabbits. By Frank M. Surface. Me. Agr. Exp. Sta., Ann. Rept. for 1913, pp. 306-313

No. 59. On the Ability of Chickens to Digest Small Pieces of Aluminum. By Maynie R. Curtis. Me. Agr. Exp. Sta., Ann. Rept. for 1913, pp. 314-318.

Papers published but not in the numbered series.

a. Methods of Poultry Management at the Maine Agricultural Experiment Station. By Raymond Pearl. Me. Agr. Exp. Sta., Circ. 471, pp. 1-78.

b. The Need for Endowed Agricultural Research. By Raymond Pearl. Science, N. S., Vol. 37, No. 958, pp. 707-709.

c. Note on the Sex Behavior of the Poitou Jacks. By Raymond Pearl. Jour. Animal Behavior, Vol III., No. 4, pp. 297-299.

d. Poultry Notes, 1911-1913. By Raymond Pearl. Me. Agr. Exp. Sta., Bul. 216, pp. 141-168.

e. The Result of Selecting Fluctuating Variation. By Frank M. Surface. Compte-Rend. IVe Conference Internationale de Genétique, pp. 221-236.

f. The Fourth International Genetics Conference. By Frank M. Surface. Amer. Nat., Vol. 47, pp. 646-640.

ENTOMOLOGICAL PAPERS FROM THE MAINE AGRICULTURAL EXPERIMENT STATION, 1913.

Ent. 60. A Note on Two Elm Leaf Aphids. By Edith M. Patch. Journal of Economic Entomology, Vol. 6, No. 3, 1913.

Ent. 61. Insect Notes for 1912. By O. A. Johannsen. Bul. 207 Me. Agr. Exp. Sta. Issued March 14, 1913.

Ent. 62. A Study in Antennal Variation. By Edith M. Patch. Annals Entomological Society of America. Vol. 6, pp. 233-236, Plates 24-27.

Ent. 63. Spruce Bud Worm and Spruce Leaf Miners. By O. A. Johannsen. Bul. No. 210 Me. Agr. Exp. Sta. Issued April 11, 1913.

Ent. 64. Potato Flea-beetle. By O. A. Johannsen. Bul. 211 Me., Agr. Exp. Sta. Issued April 11, 1913.

Ent. 65. Aphid Pests of Maine. Part II. Willow Family. By Edith M. Patch. Bul. 213 Me. Agr. Exp. Sta. Issued July 25, 1913.

Ent. 66. Food Plant Catalogue of the Aphidae of the World. Part II. By Edith M. Patch. Bul. 213 Me. Agr. Exp. Sta. Issued July 25, 1913.

Ent. 67. Woolly Aphid of the Apple. By Edith M. Patch. Bul. 217 Me. Agr. Exp. Sta.

Ent. 68. Woolly Aphids of the Elm. By Edith M. Patch. Bul. 220 Me. Agr. Exp. Sta.

Ent. 69. Food Plant Catalogue of the Aphidae of the World. Part III., By Edith M. Patch. Bul. 220. Me. Agr. Exp. Sta.

CHANGES IN STATION STAFF IN 1913.

April 1, Dr. Charles E. Lewis, Associate Pathologist, resigned to go into farming.

May 1, Mr. Walter Anderson, Poultryman, resigned to go into farming.

May 1, Miss Estella Morrison, Computer, resigned.

July 1, Miss Helen W. Averill, Assistant Chemist, resigned for a year's rest on account of her health.

April 1, Mr. Harold G. Gulliver, B. S. (Cornell) was appointed Scientific Aid in the field experiments at Highmoor Farm.

May 1, Mr. Frank Tenney was appointed Poultryman.

July 1, Miss Hazel F. Marriner, B. A. (Maine) was appointed Clerk in the Biological Department.

September 1, Mr. John Rice Miner, B. A. (Michigan) was appointed Computer in the Biological Department.

HOLMES HALL (EXPERIMENT STATION BUILDING)

The Maine Fertilizer control and Agricultural Experiment Station was established by the Maine legislature of 1885, which appropriated the sum of $5,000 a year for its maintenance. No provision, however, was made for a building for its accommodation. Although it was established as an independent institution, the trustees of the State College offered it quarters. The Board of Managers gladly accepted the offer. A laboratory was provided in Fernald Hall and an office in Wingate Hall—the wooden building, since burned, which stood where the present Wingate Hall is located. This State Station was maintained until the passage by Congress of the Hatch Bill in 1887 placed at the disposal of the University the sum of $15,000 annually for the maintenance of an Agricultural Experiment Station, after which it was discontinued.

The increase in the funds available for the support of a station permitted a considerable increase in the staff of investigation, and a consequent increase in its work, which made increased laboratory and office facilities imperative. To meet this demand, it was decided to erect a new building for the exclusive use of the Station, to be located upon the slight elevation to the east of Coburn Hall, one of the very best sites upon the campus. This building was constructed in 1887. It was built of brick with granite trimmings, and was two stories in height, with a one-story ell. In 1899 the building was enlarged by adding a wing to the south side, thus providing much needed space for food laboratories and the director's office. In the latter was placed the greater part of the station library of about 1,700 volumes.

In accordance with the plan when the building was enlarged in 1899, a wing was added on the north side in 1903. This addition restored the symmetry of the building from the front. The structure thus completed was in the form of a rectangle 46x82 feet with a reentrant angle at the southeast corner. This north wing was used for a time as a recitation room by the College of Agriculture. With the passage of the Adams Act in 1906 the increase in the staff necessitated the Station occupying the whole of the building.

In 1913, still in accordance with the plan adopted in 1899 the reentrant angle left when the addition was built on in 1903 and a two-story front porch were built.

The appearance of the building when first erected and as changed by the subsequent additions is shown in the plates. The arrangement of rooms as they now are is shown in the diagrams on pages xviii-xx. The building is 46x82 feet, two stories high, with a high basement and a large attic.

On the first floor are five chemical laboratories, two entomological laboratories, and two plant pathology laboratories.

On the second floor are four offices, occupied by the director and the administrative assistants; laboratories and offices of the biologists, a seed laboratory, a photographer's laboratory and dark room.

The basement contains two chemical laboratories, three plant pathology laboratories, rooms for the gas generator for the grinding and preparation of samples and for storage.

The large attic is used for the storage of samples, supplies, and extra copies of publications by the Station.

The building is heated by steam, lighted by electricity and supplied with gas.

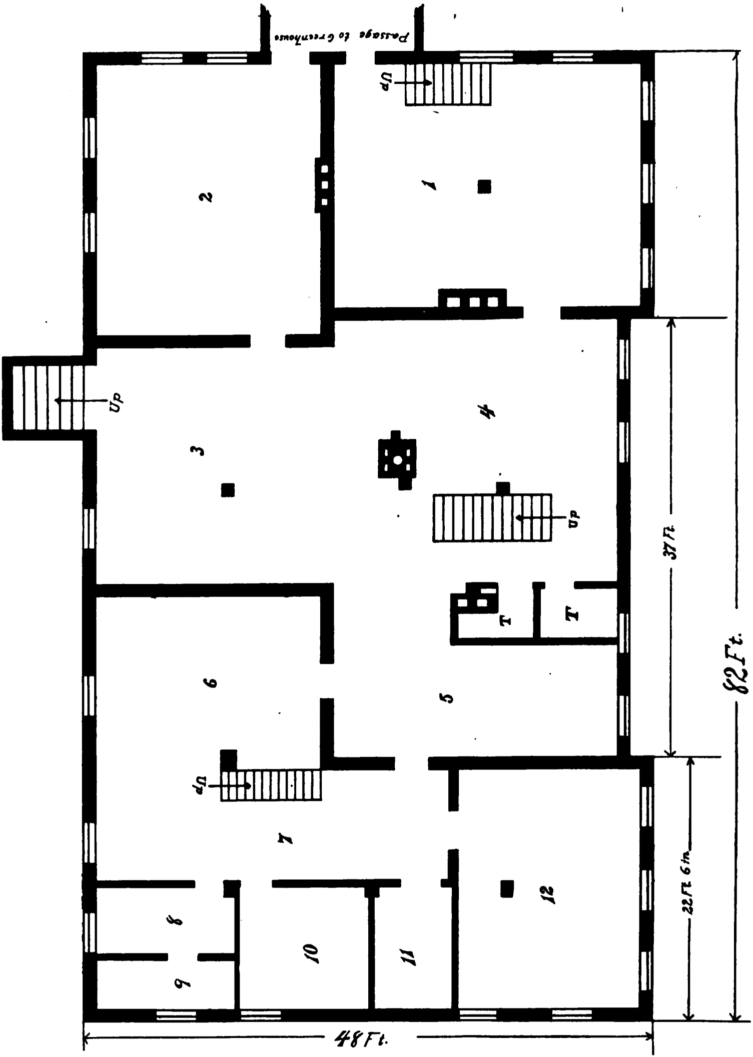
The total cost of the building was about $23,000.

In connection with the basement on the south end of the building is a greenhouse used by the plant pathologists and entomologist.

The increase in the work and force employed in the Station necessitated the removal of the Station library to the University Library in the summer of 1913.

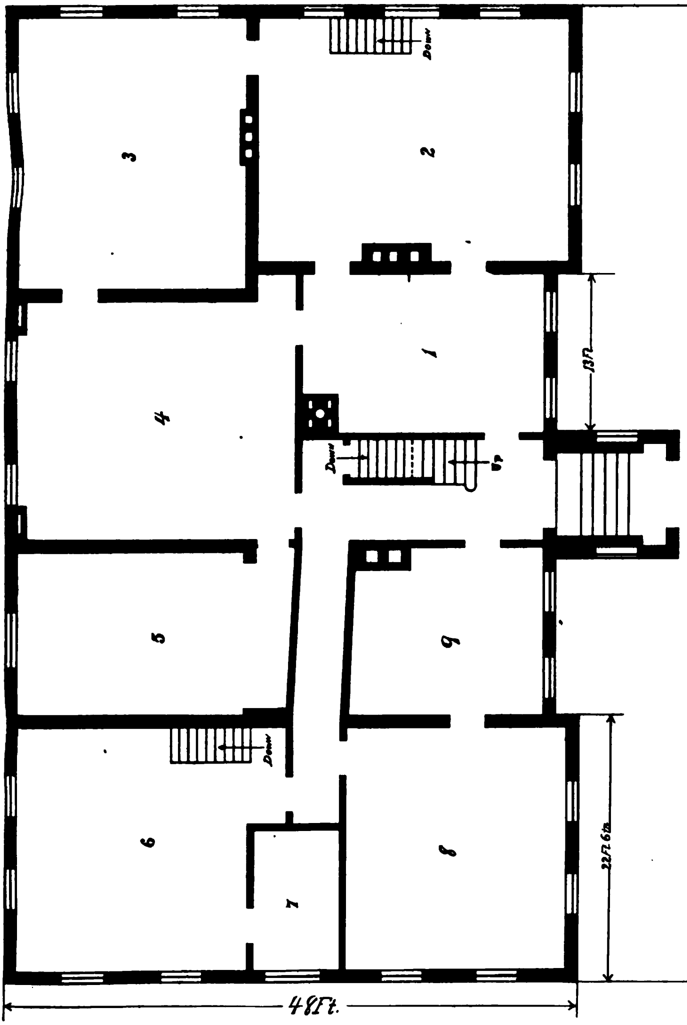
The additions in 1903 gave a dignified building designed and erected for agricultural investigations, and it seemed to the Trustees of the University eminently fitting that it bear the name of one of the most eminent pioneers in agricultural science,—Dr. Ezekiel Holmes. This honor is more deserved since Doctor Holmes nearly 70 years ago urged the entablishment in Aroostook County of a "state experiment farm" and it was largely through his efforts that the Maine Legislature of 1885 established the Maine State College as a separate and independent institution.

Holmes Hall was formally dedicated on May 25, 1904.



HOLMES HALL, BASEMENT PLAN

1 to 4 Chemistry
6 to 12 Plant Pathology
5 Gas machine

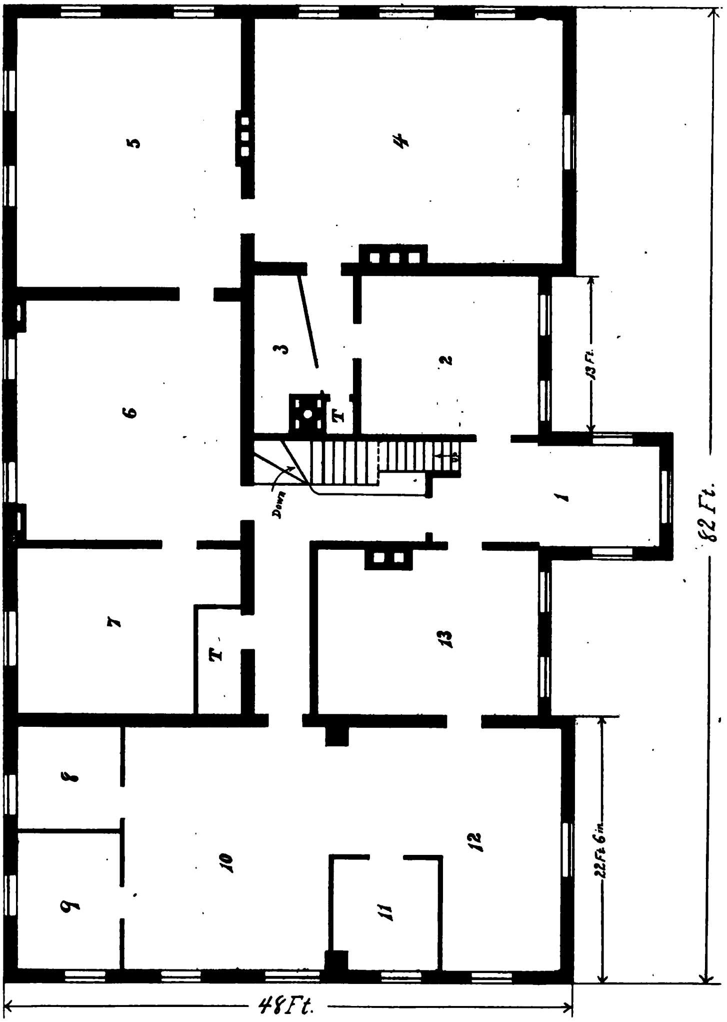


1 to 5 Chemistry

8 and 9 Entomology

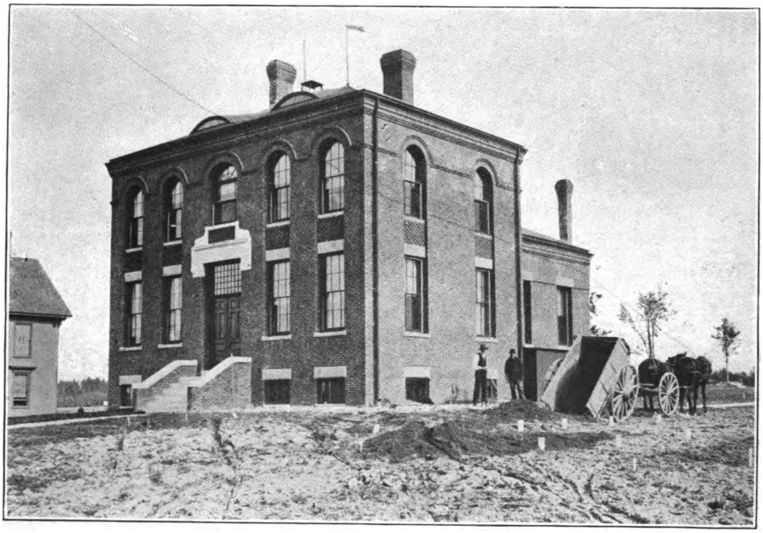
6 and 7 Plant Pathology

HOLMES HALL, FIRST FLOOR PLAN

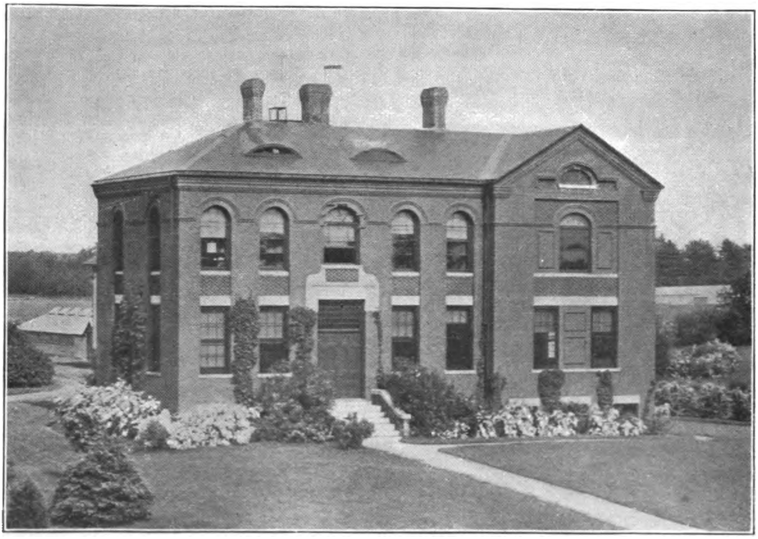


1 and 3 Photography . 2 Seed laboratory 4 to 7 Administration 8 to 13 Biology

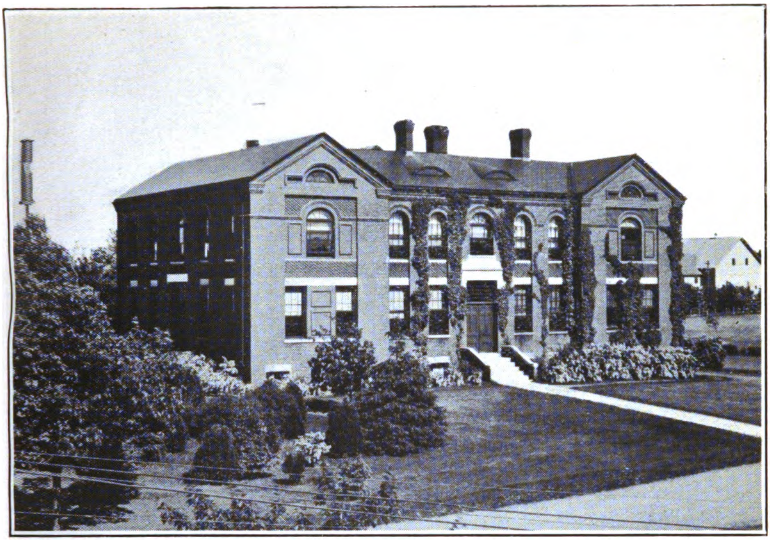
HOLMES HALL, SECOND FLOOR PLAN



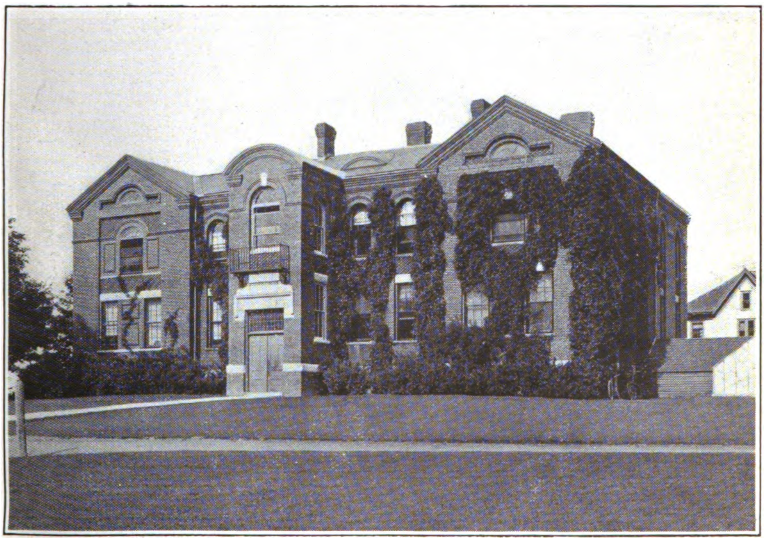
Holmes Hall, 1888.



Holmes Hall, 1899.



Holmes Hall, 1904.



Holmes Hall, 1913.

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ORONO

BULLETIN No. 209. JANUARY, 1913

NEW MINERAL FERTILIZER

This bulletin contains the account of an experiment in which corn and potatoes were grown without fertilizer, with ordinary commercial fertilizers, and with so-called New Mineral Fertilizer. The yields were the smallest where New Mineral Fertilizer was used, a little larger where no fertilizer of any kind was used, and much larger yields were obtained with regular manures.

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ORONO, MAINE.

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BULLETIN No. 209.

NEW MINERAL FERTILIZER.*

Chas. D. Woods.

For the past three years a material called at first New England Mineral Fertilizer and later New Mineral Fertilizer has been extensively advertised in New England. This advertising is of the persuasive kind and has led and may lead to still further sales at about three quarters of a cent a pound of a material which in its composition is exactly what they claim it to be, ground rock. It is this likelihood of the money of the farmer going to the coffers of the company for a material that is nearly destitute of available plant food that makes necessary the publication in the following pages of a matter that were it not for the persistent advertising might be disposed of in two pages or less. In their advertising the Company keeps within the existing laws of this State. If a bill aimed against false and misleading advertising that is now being considered by the Maine Legislature should be enacted into law it is possible that something might be done. But that is doubtful, for their advertising is ingenious and guarded. For example, they compare the analysis of the ground rock they call New Mineral Fertilizer with the analysis of a soil that produces good crops and point out the resemblances. They do not dwell upon the differences. They have the same kind of testimonials from users that are so familiar to the reader of patent medicine advertisements. But many have found the use of the goods disappointing with results similar to those here reported. Such instances are not reported in the company's advertisements.

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* This experiment was planned by the writer. The field work was executed under the direction of Mr. Sinclair. The notes were taken by Mr. Bonns.

Station for the first time in its history an opportunity to make spraying experiments on a large scale in an orchard entirely under its control. By this time the results of experiments made in other parts of the country indicated that a concentrated mixture of lime and sulphur in water, cooked by artificial heat and then diluted before applying, was the most promising lime-sulphur spray for apple orchards. It was claimed to be more effective than the self-boiled article and entirely free from spray injury, thus, in this respect, being much superior to bordeaux mixture.

Therefore an experiment was planned for 1910 as one of the plant pathology projects for that year in which it was proposed to test the value of artificially boiled or cooked lime-sulphur as an orchard spray, as compared with the self-boiled and with bordeaux mixture. Also it was planned to test the relative efficiency of several commercial brands of concentrated, boiled lime-sulphur as compared with the home-cooked article. With the appointment of Mr. W. W. Bonns as Station Horticulturalist, stationed at Highmoor Farm, the project was transferred to his department. Mr. Bonns carried on two series of experiments, one in 1910 and one in 1911, the results of which were quite fully reported in Bulletins 189 and 198. In the first publication, in addition to giving an account of the results of the experimental work of the season, he reviewed in considerable detail the literature upon the use of lime-sulphur as a summer spray, the use of sulphur and its compounds as fungicides, the question of spray injury from bordeaux mixture, etc. On account of the great demand for Bulletin 189 it was soon out of print. Therefore a summary of the experimental results obtained in 1910 were included in Bulletin 198 with those obtained in 1911.

The apple orchards at Highmoor Farm consist almost entirely of the Ben Davis and Baldwin varieties. The entire orchards were sprayed once late in June 1909 with bordeaux mixture and arsenate of lead, largely to control leaf-eating insects, just as soon as it was found that the purchasing committee had decided to buy this farm. So far as known this was the first time the trees, which were then in a much neglected, half-starved condition, had ever been sprayed. In 1910 all but the experimental plots received three applications of bordeaux mixture and arsenate of lead. During both seasons much damage from spray injury resulted to both foliage and fruit, particularly on the Ben Davis. Since 1910 the main orchards have been sprayed yearly with home-cooked lime-sulphur and with uniform success as far as spray injury was concerned.

On account of weather conditions no real severe test of lime-sulphur as a means of control of apple scab was experienced until the present year, although the data secured in 1910 were sufficiently conclusive for practical purposes with regard to certain questions under consideration. The artificially cooked lime-sulphur gave that year, as a rule, much better results as to scab control than did the self-boiled article. The results in 1910 were also slightly in its favor in this respect when compared with bordeaux mixture. The commercial brands of concentrated lime-sulphur were, during that season, somewhat more effective than the home-cooked material, but this advantage was not considered sufficient to offset the greater cost of the former for large orchards.

With regard to injury to foliage and fruit all of the lime-sulphur sprays proved to be much more satisfactory than bordeaux mixture, although one proprietary spray, the name of which indicated that it was some sort of a sulphur compound, produced much greater spray injury than did bordeaux mixture. However, in these orchards of over 2300 trees, mostly Ben Davis and Baldwin, wherever bordeaux mixture has been used during the past four years the resulting injury to foliage and fruit has, as a rule, more than offset the benefits derived from fungus control. It will be seen later that during 1912, while the foliage escaped, much russeting was produced on the fruit. On the other hand, properly made and properly applied lime-sulphur has produced practically no foliage injury and very little russeting of the fruit could be attributed to it. At the same time when applied at the proper time, particularly in the experiments to be described in this bulletin, it was quite effective in the control of the apple scab fungus on both foliage and fruit.

While it has been shown conclusively in these experiments and those conducted elsewhere that lime-sulphur is a much safer spray to use on those varieties of apples like the Ben Davis which are very susceptible to spray injury, there are certain varieties of apples which are not injured or are but slightly injured by bordeaux mixture. Moreover the work of Stewart and his associates of the New York Station has shown that lime-sulphur not only is far inferior to bordeaux mixture as an agent to control the late blight and other potato leaf-diseases, but it is apparently positively detrimental to the potato.* Therefore it seemed justifiable to plan a series of experiments extending over a number of years in which the relative efficiency of bordeaux mixture and lime-sulphur as a spray for apple orchards could be tested under a variety of seasonal weather conditions. While the reports are everywhere quite favorable to lime-sulphur, as an orchard spray the data so far accumulated are not sufficiently varied and complete to draw final conclusions. If bordeaux mixture is more effective or even equally effective in scab control there is no reason for the orchardist who experiences no injury from it upon the varieties which he grows to discard it in favor of lime-sulphur.

Certain writers, a summary of whose work Mr. Bonns gave in Bulletin 198 have noted the fungicidal value of lead arsenate.† Therefore the experiments for 1911 were so planned as to include a test of the fungicidal value of lead arsenate, further comparisons of the fungicidal value of bordeaux mixture and home-cooked lime-sulphur, and a test of different dilutions of lime-sulphur to determine which is the most satisfactory strength to use, both with regard to control of scab and freedom from spray injury. The variety used for making these tests in all cases being the Ben Davis.

On account of weather conditions being unfavorable to the growth of the fungus practically no scab developed in the orchards in 1911 so that from that standpoint no data of value was secured. In fact on account of the failure of scab to develop the only clear-cut result of the experimental spraying of that year was with regards russeting the fruit. Where bordeaux mixture was used over 70 per cent of the apples were so affected while on the other plots this was not over 2 per cent in any case and the amount was fairly uniform, regardless of the kind and strength of the spray.

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* Stewart, F. C. and French, G. T., Lime-Sulphur vs. Bordeaux Mixture as a Spray for Potatoes. Bul. N. Y. Agr. Exp. Sta. 347, 1911. Munn, M. T., Lime Sulphur vs. Bordeaux Mixture as a Spray for Potatoes II. Bul. N. Y. Agr. Exp. Sta. 352, 1912.

† Taylor, E. P., Spraying Peaches for Brown Rot, Western Fruit Grower, pp. 20-21, Oct. 1909, pp. 16-18, Feb. 1910.

Wait, M. B. Experiments on the Apple with Some New and Little Known Fungicides, Cir. U. S. D. A. Bu. Pl. Ind. 58, 1910.

Wallace, E., Blodgett, F. M. and Hessler, L. R. Studies of the Fungicidal Value of Lime Sulphur. Bul. Cornell Agr. Exp. Sta. 290, 1911.

THE 1912 EXPERIMENTS.

In 1912 the apple spraying experiments were again transferred to the Department of Plant Pathology. When the first two applications of the spray were applied in the experiments which will be described the Station pathologist was on a leave of absence, otherwise an unsprayed check-plot would have been saved for comparison. That part of the work which was primarily concerned with the fungicidal value of the different sprays was an exact duplicate of that carried out the season before, but as has already been pointed out the weather conditions of the summer of 1912 were much more favorable to the test.

In this experiment there were used 139 Ben Davis trees, about twenty-five years old and which constituted a block at one corner of the most thrifty orchard on the farm. This is the same block of trees which was used in 1910 and 1911 experiments. Previous to 1909 this orchard, like the others on the farm, had been much neglected, although it showed some evidence of previous cultivation and had also been used for a sheep pasture in recent years. For the past three years it has been well fertilized and has been thoroughly cultivated each year. It is now in a quite thrifty condition. The block was divided into six different plots.

Plot A was sprayed with arsenate of lead 4 pounds in 50 gallons of water.

Plot B was sprayed with home-cooked lime-sulphur, 27° Beaumé density 2 gallons, in water sufficient to make 50 gallons. This was called the "one-fifth stronger" plot as the spray carried 20 per cent more of the concentrate than is commonly recommended.

Plot C or the "standard dilution" plot was sprayed with 1 2-3 gallons of the same lime-sulphur concentrate, diluted with water to make 50 gallons. This is the same dilution as is used on the general orchards on the farm.

Plot D was called the "one-fourth weaker" plot as only 1 1-4 gallons or 25 per cent less of the concentrate than in Plot C was used to each 50 gallons of the spray.

Plot E was sprayed with 2 pounds of arsenate of lead in 50 gallons of water.

Plot F was sprayed with a 3-3-50 bordeaux mixture.

Two pounds of arsenate of lead were added to the spray in each case on plots B, C, D and F. All of the sprays were applied with a gasoline power sprayer outfit, using two leads of hose at a time at about 150 pounds pressure. Care was taken to thoroughly wash out both the tank and the pump after using each different kind of spray, before putting in the next. The relative position of the plots and the number of trees in each are best shown in the following plan.

PLAN OF EXPERIMENT.

			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	A		B						C						D						E		F	

A. 9 trees, arsenate of lead 4 lbs. to 50 gallons.
B. 35 trees, lime-sulphur 2 gallons in 50, 2 lbs. arsenate of lead.
C. 36 trees, lime-sulphur 1⅔ gallons in 50, 2 lbs. arsenate of lead.
D. 35 trees, lime-sulphur 1¼ gallons in 50, 2 lbs. arsenate of lead.
E. 12 trees, arsenate of lead 2 lbs. to 50 gallons.
F. 12 trees, 3–3–50 bordeaux mixture, 2 lbs. arsenate of lead.

As originally planned three applications of the sprays were to be made, the first just as the blossoms were showing pink, the second after the petals fell and the third about three weeks later. The early part of the season was very wet and for several days before the first application should have been made it rained almost constantly. Partly on this account and partly on account of a misunderstanding on the part of those in charge of the work at that time the first application of the sprays on the experimental plots was delayed so long that the blossoms opened before it could be applied. Fortunately, on the orchard adjoining the plot, where exactly similar conditions existed with regards soil, age, variety and condition of the trees, this first application was made just before the blossoms opened. Hence this furnished opportunity to select a plot of trees sprayed three times with standard dilution lime-sulphur and where the applications were made at the proper dates as was intended in the original experiment. As will be seen later the results from this block of trees furnished an excellent demonstration, when compared with the other experimental plots, of the value of a fungicidal spray for apple scab when applied just before the blossoms open. This plot will be referred to as Plot G.

Plots A to F inclusive were sprayed first on June 5 and again on July 1. Plot G was sprayed on May 24, June 5 and July 1.

EFFECT OF THE SPRAYS ON THE FOLIAGE.

The experimental plots were under the constant observation of the orchardist, Mr. Yeaton, and were frequently visited by Dr. Lewis, the associate pathologist, and the writer during the season.

On June 5 there was no evidence of scab in any of the orchards. On plot G where the first application of lime-sulphur was made on May 24 there was no evidence of spray injury although an occasional leaf showed scorching at the margin.

Plot A, 4 pounds of arsenate of lead with no fungicide, showed a small amount of scab on the leaves of all of the trees, some leaves being quite badly affected on the first of July. No spray injury was noted at that time. By the middle of July the scab had not developed much more but there was by this time abundance of spray injury on the leaves. By August first the foliage still plainly showed the effects of spray injury but the evidences of scab on the leaves had largely disappeared. A record was also kept on the appearance and development of scab on the fruit on this and other plots but this will be discussed under another heading.

Plot B, sprayed with 2 gallons of lime-sulphur and 2 pounds of arsenate of lead diluted to 50 gallons, showed a quite general infestation of scab on the leaves by July 1. However, while some of the leaves on all of the trees in this plot were attacked, the infestation was, on the whole, recorded as slight as compared with plots C. D. and E. By the middle of July there was not much evidence of farther development of scab, but some spray injury was plainly evident on the foliage. This was, however, frequently plainly associated with scab spots and suggested that it might be analogous to arsenical injury on potato leaves which have been injured by flea beetles. A given amount of Paris green or other arsenical may be used on potato plants with perfect safety so long as the epidermis of the leaves is unbroken. On the other hand, if a considerable number of flea-beetle punctures are present in the leaves arsenical injury is quite likely to result, the severity of the injury varying with the number of punctures.

By August 1 the evidence of scab infestation on this plot had largely disappeared and no increase of the amount of spray injury on the foliage was observed during the remainder of the season.

Plot C sprayed with 1 2-3 gallons of lime-sulphur and 2 pounds of arsenate of lead diluted to 50 gallons. Detailed records made of the amount of scab on the leaves of the individual trees in this plot at various times during the season showed relatively more scab was present than on plot B, where the "one-fifth stronger" dilution of lime-sulphur was used. On the other hand very little leaf-spot or spray injury was observed on plot C.

Plot D, sprayed with 1 1-4 gallons of lime-sulphur and 2 pounds of arsenate of lead diluted to 50 gallons. Much more scab was observed on this than on any of the other lime-sulphur plots. Judging from the appearance of the leaves alone, and in comparison with plot E the two applications of this weaker dilution of lime-sulphur failed to exert any restraining influence on the development of the scab fungus whatever, although it will show later that it did reduce somewhat the amount of scab on the fruit.

Plot E, sprayed with 2 pounds of arsenate of lead in 50 gallons of water. With the exception of plot D this showed the greatest development of scab on the foliage of any. In this connection it should be noted that there was a decidedly less amount of scab on the leaves of the trees in plot A where double the amount of arsenate of lead was used without any lime-sulphur. In fact on the last mentioned, considering plot E as a check, the control of scab on the foliage was fully equal to that on the "standard dilution" plot and nearly equal to that on the "one-fifth stronger" plot.

Plot F, sprayed with a 3-3-50 bordeaux mixture. During the present season if final conclusions were to be based on the effects on the leaves alone bordeaux mixture showed much better results than lime-sulphur. However the final record of the percentages of perfect and imperfect fruit, which are given later, tell a somewhat different story. On plot F, where bordeaux mixture and arsenate of lead was used there was almost perfect control of scab on the foliage and no spray injury of the leaves was observed. On the other hand very severe spray injury to the leaves was experienced on the same variety in previous years.

Plot G, sprayed with "standard dilution" lime-sulphur the same as plot C, except that it received an application on May 24, just before the flower buds opened. On this plot throughout the season the control of scab on the leaves was all that could be asked for, and little or no spray injury was apparent.

EFFECT OF THE SPRAYS ON THE FRUIT.

Notes and observations were made and records kept of the development of scab and the appearance of russeting on the fruit during the season. These records do not give any additional information which is of material value and which is not indicated by the condition of the fruit at the time of harvesting, therefore they are omitted.

The fruit on the trees on the experimental plots under consideration averaged about 3 barrels per tree, giving on the entire area over 400 barrels. So far as could be observed the condition of the fruit on the different trees in each plot was fairly uniform, therefore it seemed to be an unnecessary expenditure of time and labor to attempt to sort and count the entire quantity. For the purpose of obtaining the necessary data the entire crop on 6 trees in each plot was picked separately, placed in barrels and taken to the packing shed for sorting. In all plots except A, E, and F, where this was impossible, the 6 trees constituted one of the rows nearest the center of the plot. The amount of fruit actually used and counted to obtain the data recorded in the following table amounted to about 20 barrels per plot or treatment. In some cases it ran over this and in others, notably in plot G, it was somewhat less than 20 barrels.

It will be noted in the table that in plot E the percentages total slightly more than 100 while in plot F they amount to considerably more than this. This is accounted for by the fact that in some cases, particularly in plot F the same apples were both scabbed and russeted.

RESULTS OF THE FUNGICIDE EXPERIMENTS ON THE FRUIT.

Plot.	TREATMENT.	Total No. of apples.	Number smooth.	Number scabby.	Number russeted.	*Per cent. of perfect apples.	*Per cent. of scabby apples.	*Per cent. of russeted apples.
A	Arsenate of lead 4 lbs.—water 50 gallons	10,507	7,132	2,660	715	67.8	25.3	6.8
B	Lime-sulphur 2 gals.—arsenate of lead 2 lbs.—water 48 gals	10,298	7,409	2,520	369	71.8	24.4	3.5
C	Lime-sulphur 1⅔ gals.—arsenate of lead 2 lbs.—water 48⅓ gals.	9,312	4,727	4,439	146	50.7	47.6	1.5
D	Lime-sulphur 1¼ gals.—arsenate of lead 2 lbs.—water 48¾ gals.	9,513	3,450	5,835	228	36.2	60.9	2.3
E	Arsenate of lead 2 lbs.—water 50 gals	9,935	1,859	8,044	52	18.7	80.6	2.3
F	Bordeaux mixture 3-3-50—arsenate of lead 2 lbs	9,363	5,959	3,048	3,404	63.6	32.5	35.3
G	Lime-sulphur 1⅔ gals.—arsenate of lead 2 lbs.—water 48⅓ gals.†	6,733	5,985	95	650	88.8	1.4	9.6

* The per cents. do not total 100 as in some instances a considerable number of the same apples were both scabby and russeted.

† Like plot C except that an application was made just before the flower buds opened.

DISCUSSION OF RESULTS.

As has already been mentioned the original plan of the experiment called for an application of the various sprays when the flower buds began to show pink, or before they opened. The failure to do this greatly lessened the value of the data which it was planned to obtain. Fortunately, however, this omitted spray was applied to the adjoining orchard from which plot G was taken. As a result certain other data were obtained which are doubtless of more practical value than that originally desired.

Efficiency of the first spray application. Perhaps the most striking thing about the results secured is with regards the value of the spray applied before the blossoms opened as compared with the two following applications. This is shown by the figures obtained on plots C and G. The treatment on these two plots being exactly alike except that on C the first spraying was omitted. In one case only about 50 per cent of perfect apples were obtained and nearly all of the remainder of the fruit was scabbed. In the other nearly 90 per cent of the fruit was sound and perfect and less than 1.5 per cent was scabby. It is true that on the last plot nearly 10 per cent were classed as russeted but this figure is somewhat misleading as the russeting was, as a rule, very slight. Very few of these so-called russeted apples would have to be sold for less than a No. 2 grade.

The general conclusion was that, under the existing weather conditions of the past season, where the first spraying was omitted the profits derived from the two following sprayings paid little more than the cost of application. This statement should not be taken as implying that these are not important or advising that they should be omitted, but as pointing out the great importance of the first spraying, applied at the proper time. The more complete knowledge of the life history of the scab fungus which has been gained in recent years coincides with these experimental results.

The fungus passes the winter on fallen leaves under the trees. In early spring on these leaves of the season before it matures within a capsule an entirely different type of spore from that which leads to the propagation and spread of the fungus during the following summer. These sac spores are thrown out in the spring in large numbers, are carried to the leaves of the lower branches of the trees, and there serve as centers of infection as soon as they have germinated and have begun to produce a diseased area. This period of ejection of the sac spores lasts but for a comparatively short time and then the danger from them is largely past. Consequently if a fungicidal spray is applied to the trees when these spores are being matured and thrown off, or at least before they have germinated and infected the leaves and parts of the young blossom buds, a large proportion of the potential possibilities of scab infestation for the coming season will be eliminated at the start. If, on the other hand, the first application is too long delayed and infection has occurred no amount of later spraying will absolutely control the disease although it may do much to prevent its spread to uninfected fruit and leaves.

That two applications of standard dilution lime-sulphur did materially check the development of scab is plainly shown in comparing plots C and E where the former gave 32 per cent more perfect apples than the latter. On the other hand plot G, sprayed three times, gave a like increase of over 70 per cent. This much greater efficiency in disease control is very evidently due to the prevention of the early spring infection from the sac spores produced on the old leaves under the trees.

Dilution of lime-sulphur. The fact that only two applications were made to the different plots of which the different dilutions of lime-sulphur were tested detracts from the value of the data obtained. While too sweeping conclusions should not be drawn from them, the results taken for their face value are fairly suggestive. The "one-fifth stronger" dilution was decidedly more efficient in scab control than was the "standard dilution" and produced but little more russeting of the fruit. This did, as has been previously noted, produce some slight leaf injury. Judging from this season's experience and that of the year before it would seem that a 27° Baumé lime-sulphur can be used at the rate of two gallons to 48 of water with comparative safety on varieties like the Ben Davis which are very susceptible to spray injury. Judging from the results of the present season alone this stronger dilution is much more efficient than the standard dilution in scab control—possibly sufficiently so to warrant its use in commercial spraying. However this is a matter which requires more confirmatory evidence.

The "one-fourth weaker" dilution on plot D proved to be entirely inefficient in scab control and doubtless what gains there were did not pay the cost of spraying. While it is very likely that much better results would have been obtained if another application of this spray had been made earlier it is not felt that the results are sufficiently encouraging to warrant following it farther another year.

Lime-sulphur vs. bordeaux mixture. The percentage of perfect apples obtained from the plot sprayed with bordeaux mixture exceeded that produced on those plots sprayed with lime-sulphur the same number of times with the exception of plot B where the strongest lime-sulphur spray was used. Here again, however, the figures do not tell the whole story. Strange as it may seem, practically all of the scabbed apples on the bordeaux sprayed plot were also among the russeted. However, very few of the apples on this plot were very badly affected with scab. On the other hand the scabbed apples on the lime-sulphur sprayed plots were, as a rule, somewhat more seriously affected. While the slightly scabbed apples on the bordeaux plot would doubtless keep in storage better than the slightly more severely attacked fruit on the lime sulphur plots the latter fruit on account of its freedom from spray injury or russeting would bring a higher market price.

Arsenate of lead as a fungicide. Another very striking fact in connection with results obtained was the apparent effectiveness of heavy applications of arsenate of lead in the control of apple scab as is shown by a comparison of the per cent of scabby apples recorded from plots A and E. In one case where 4 pounds of arsenate of lead to 50 gallons of water was used with no other material added as a fungicide only a little over 25 per cent of the fruit was scabbed while in the other case where only half as much arsenate of lead was applied over 80 per cent of the apples were scabby. Moreover it will be seen on reference to the table that where the 4 pounds of arsenate of lead was used alone the percentage of perfect apples obtained was greater than on all other plots which received the same number of applications except B, where the stronger dilution of lime-sulphur was used.

It was in connection with these comparisons that the lack of an unsprayed check-plot was most apparent. Apparently when plots A and C are compared, 4 pounds of arsenate of lead were decidedly more effective in scab control than standard dilution lime-sulphur plus 2 pounds of arsenate of lead. If 4 pounds of arsenate of lead exerts so decided a fungicidal effect, is it not possible that the amount of scab on plot E, sprayed with 2 pounds of arsenate of lead alone, is considerably less than would have developed on an unsprayed plot? If such is the case its use as a check plot does not measure the true fungicidal value of sprays used on the other plots. Similarly how much of the fungicidal value of lime-sulphur combined with arsenate of lead is due to the presence of the last named material? There is one outside factor which may have exerted an influence on the apparent effectiveness as a fungicide of the heavy application of arsenate of lead. As is illustrated on p — the nine trees in this plot were at the corner of the orchard and were thus much better exposed to the sunlight than those on the other plots. However it does not seem that this location with regards light is sufficient to account for the recorded differences.

EXPERIMENTS WITH DIFFERENT ARSENICALS IN COMBINATION WITH LIME-SULPHUR.

The ordinary arsenate of lead paste commonly used for orchard spraying is a very variable substance. Some lots as purchased may be quite soft and carry a considerable percentage of water. Other lots, sometimes from the same manufacturer, are received in the form of a rather dry, sticky paste. This variation in composition may cause considerable variation in the amount of arsenate of lead actually used in the spray no matter how careful the user is to accurately weigh the quantity taken. Also considerable difficulty is frequently experienced in disolving the arsenate of lead paste, particularly that which has partially dried out, so that it will mix thoroughly and well with the spray. Certain manufacturers are now selling a dry arsenate of lead in powder form which dissolves readily and quickly in water and which, if not adulterated, should always carry the same amount of poison pound for pound. Arsenite of zinc is also being sold as a substitute for arsenate of lead.

While the use of these substances as a substitute for the ordinary form of arsenate of lead as an insecticide is primarily a problem of economic entomology, their effects upon foliage and fruit, injurious or otherwise, are matters which concern the pathologist. Therefore an experiment was conducted, with the object in view of determining whether or not these substitutes produce injurious effects, in which the ordinary form of arsenate of lead paste was compared with the dried or powdered arsenate of lead and the arsenite of zinc.

For this Ben Davis trees were used in blocks of 36 trees each. The records were taken on the fruit from one row of 6 trees near the center of the plot as was the case in the fungicide experiments. So far as could be observed none of the insecticides, all of which were used in connection with standard dilution lime-sulphur, produced any appreciable injury to the foliage. Three pounds of arsenate of lead paste, 1 1-2 pounds of the dry arsenate of lead and one pound of arsenite of zinc were used with each 50 gallons of the lime-sulphur spray. The following gives in tabular form the condition of the fruit when harvested.

RESULTS OF THE INSECTICIDE EXPERIMENTS ON THE FRUIT.

TREATMENT.	Total No. of apples.	Number sound.	Number wormy.	Number russeted.	Per cent. of sound apples.
Arsenate of lead paste................	6733	6080	3	650	90
Arsenate of lead dry................	3594	3383	2	209	94
Arsenite of zinc....................	5790	5485	5	300	93

In the above table the term "sound" is used to include all apples which were not attacked by insects and were not russeted. In this experiment no account was made of scabby fruit.

DISCUSSION OF RESULTS.

The results set forth in the above table are so self-evident that very little discussion is necessary. It will be seen that with regards insect control the three different insecticides produced almost exactly identical results. It may be said in this connection that not one of the apples classed as "wormy" was attacked by the codlin-moth but by the lesser apple worm. It will also be seen on comparing the per cents of sound fruit that the two substitutes produced even better results with regard to russeting than did the arsenate of lead paste, although these differences are probably within the limits of experimental error. So far as can be judged from the data obtained by this one experiment dry arsenate of lead and arsenate of zinc are fully as effective and are as safe to use as arsenate of lead paste. The results of the experiment, were on the whole so satisfactory, both with regards insect control and ease in mixing with the spray liquid, that dry arsenate of lead will be used on all the orchards at Highmoor Farm in 1913.

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ORONO

BULLETIN No. 213 JUNE, 1913

APHID PESTS OF MAINE II. WILLOW FAMILY

CONTENTS.

This bulletin contains a descriptive account of Maine aphides infesting the plants of the willow family, accompanied by a list of aphides recorded from other parts of the world on the corresponding plants. Three species are described as new.

Remedial measures are discussed on pages 91 and 92.

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BULLETIN No. 213.

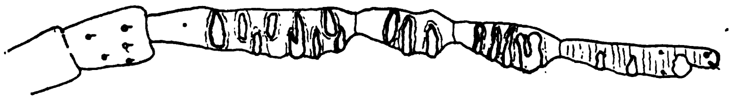
APHID PESTS OF MAINE. PART II.*

EDITH M. PATCH.

WILLOW FAMILY.

It is interesting to note that the aphides attacking willows and poplars are restricted to comparatively few genera. Many of the species are troublesome on shade and ornamental trees. The complete life cycle of certain gall forming species of the poplar is not yet known, but with *Pemphigus betae* (Gillette 1912) traced to the cottonwood for its winter host we have a stimulus for ascertaining whether the poplar serves as alternate host for other species of economic importance to vegetation outside of the willow family itself.

Pemphigus populimonilis Riley. The galls of this species are so familiar and characteristic with their bead like rows of cells each containing a single occupant, that *populimonilis* has been free from synonymic difficulties. Fig. 47.



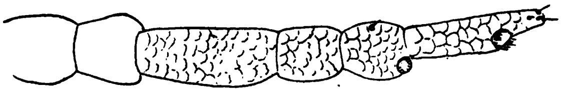


Fig. 20. *P. populimonilis.* Antenna of spring migrant.

Fig. 21. Antenna of pupa drawn to same scale as Fig. 20.

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* Papers from the Maine Agricultural Experiment Station: Entomology No. 65.

Alate viviparous female,—Spring migrant. From late July until mid-August this form can be found winged and solitary in the gall which it is now ready to desert. Fig. 20 shows the antenna of this form and Fig. 46 D. the wing. Fig. 21 is a drawing of the antenna of the pupa, the joints IV and V of which are typically rather short and bulging, and VI longer, narrower and with nearly parallel margins.

Apterous viviparous female,—Stem mother. This form has not previously been recorded. I first took it in 1905 and have met with it since though the galls of the progeny so far outnumber those of the stem mother that many occur to one containing the apterous parent. Sometimes the stem mother is present in one of a chain of galls containing pupae, but often she is found in a single gall separate from those occurring in a chain but not differing from them in structure or appearance,—at least there is not enough difference so that those containing the stem mother can readily be separated without examining the insect itself.

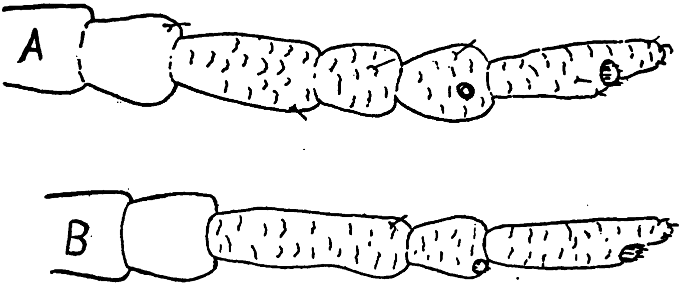


Fig. 22. *P. populimonilis.* Antenna of stem-mother.

The antenna of this form (Fig. 22) is ordinarily 6-jointed though sometimes, as is often the case with stem mothers of allied species, there is some irregularity in the development of the antenna and it appears with 5 joints. The joints have the same rotundity as in the pupa, a character accentuated by the shortness of IV and V which are literally about as broad as they are long.

Collection data for this species are as follows: 46-05. *Populus balsamifera.* Aug. 15, 1905. Veazie, Me. Several stem mothers taken singly in galls but these were dead either from parasitic insect or fungous attack. Winged form and pupæ were present in other galls, and a species of *Chaitophorus* was populating galls deserted by this *Pemphigus*.

86-06. *Populus balsamifera*. July 26, 1906. Veazie, Me. A single winged specimen in each small gall except where the gall was already vacated or occupied by a syrphus maggot.

81-09. *Populus balsamifera*. July 22-27, 1909. Veazie, Me. Galls very numerous. A single leaf was found bearing 65 galls. Four stem mothers, numerous pupæ and winged migrants still in galls,—each solitary.

99-12. *Populus balsamifera*. July 18, 1912. Veazie, Me. Galls numerous each containing a single insect in pupal stage.

Pemphigus gravicornis n. sp. For the past three years the pseudo-galls of this species have been common on *Populus balsamifera*. The affected leaves are folded lengthwise along the midrib and their margins are applied together at their ventral surfaces. The whole leaf except at the margin is swollen into a large sac or pocket which is filled with aphides. Fig. 53. This gall resembles that of *populiconduplifolii* but the two aphides are readily separated on antennal characters. So far as my observations go the galls of *gravicornis* occur on leaves anywhere on the tree while those of *populiconduplifolii* are on terminal leaves only.

Winged viviparous form.—Spring migrant, with antennal joints III, IV, V heavily charged with large irregular sensoria giving them a knurled appearance; and VI very slender and ordinarily without sensoria except the usual one at base of spur, though one or more others may be present. Fig. 23.

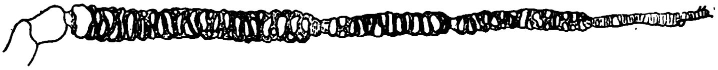


Fig. 23. *P. gravicornis*. Antenna of spring migrant.

The wings are delicate and the veins faint. Fig. 46 H. No description has been made of the living specimens, but the peculiar antennæ will serve to distinguish this species.

Collection data are as follows:

87-06 July 26, 1906. Veazie, Me.; 26-11 July 7, 1911, Orono, Me.; 98-12 July 18, 1912, Veazie, Me. Pupæ and migrants were taken but no stem mothers in these collections. The deserted galls are frequently appropriated by colonies of *Chaitophorus*.

Pemphigus populiconduplifolius Cowen. The galls of this species resembles that of *gravicornis* closely. Fig. 52. Sometimes galls of this species instead of being folded along the midrib are all on one side of the midrib in which case they are elevated above the level of the surface, and like those of gravicornis the ventral surface of the leaves forms the inside of the gall. Galls are pale green tinged with red and have a swollen appearance. The terminal leaves are those ordinarily attacked.

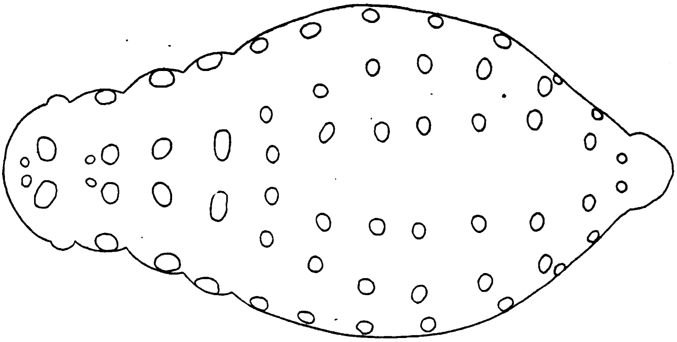


Fig. 24. *P. populiconduplifolius.* Wax gland areas of stem-mother.

Apterous viviparous female,—Stem mother. The wax gland areas of this form are shown in Fig. 24 and the antenna in Fig. 26. This insect is globular, dark greenish blue and woolly.

Winged viviparous form,—spring migrant. The antenna of this form is shown in Fig. 25 and the wing in Fig. 46 c.

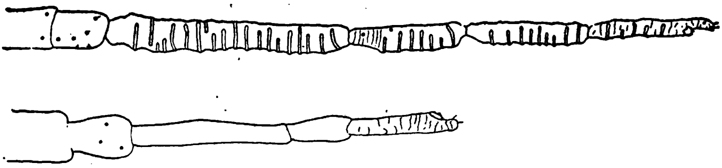


Fig. 25. *P. populiconduplifolius.* Antenna of spring migrant.
Fig. 26. Antenna of stem-mother.

Collection data are as follows:—23-06 (in part) June 14, 1906. Stem mothers; 37-10 June 29, 1910, Veazie, Me. Pupæ numerous and some migrants just winging; 46-10, 47-10, July 5, 1910, Veazie. One stem mother and numerous pupæ and winged forms. 91-12, a single stem mother in each gall with several nymphs, Orono Campus. 110-12, July 15, 1912, Orono, same tree as 91-12 and probably some of the same lot. Winged forms numerous. *Populus balsamifera.*

Pemphigus populicaulis Fitch. This species is structurally very close to *bursarius.* A few of the galls are shown in Figs. 49, 50, and 51. As will be noticed these are formed near the midrib and may be at the base of the leaf or elsewhere along the midrib, the opening being sometimes on the ventral (Fig. 49) and sometimes on the dorsal surface (Fig. 51). The galls vary considerably in size and in shape though they are more or less globular. This species is common on *Populus balsamifera* in this vicinity.

Winged viviparous female,—spring migrant. The wing of this form is shown in Fig. 46 I. and the antenna in Fig. 27. It will be noticed that joint VI is as heavily annulated as the other joints. I have specimens from Minnesota and Texas which accord with the Maine material and the figures of California specimens (Essig 1912) show the same characters as typical.

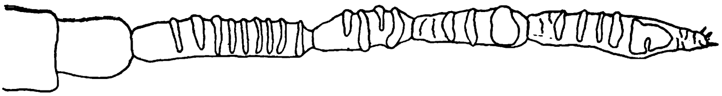


Fig. 27. *P. populicaulis.* Antenna of spring migrant.

Collection data are as follows:—23-11, Orono, July 6, 1911. Winged forms in galls.

101-12, July 18, 1912, Veazie. Galls on stem at base of leaf (Fig. 50) causing a twist in the stem. Opening on the ventral side. Galls are more or less pinkish and some are decidedly reddish.

102-12 Veazie, July 18, 1912, galls on ventral side of leaf opening on dorsal surface, greenish or occasionally pinkish. They measured from half an inch to three-quarters of an inch along the mid-rib. Fig. 51.

103-12, Veazie, July 18, 1912. Pinkish galls along the midrib on the dorsal side opening on the ventral surface. Fig. 49.

Pemphigus bursarius Linn? A species closely allied to, if not identical with *bursarius* of Europe (Tullgren 1909) is common on poplar here. The life cycle is not ascertained but breeding tests for an alternate host are planned. The antenna and wing are represented by figures 28 and 46 B.

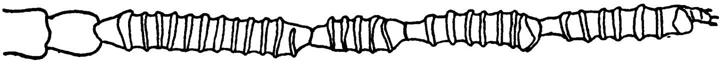


Fig. 28. *P. bursarius.* Antenna of spring migrant.

The gall is found on the petiole of the leaf in the form of irregular swellings of varied size, anywhere from near the base of the leaf to the extreme proximal end of the petiole. Gall causes curve in the petiole or sometimes a confused twist where two or three galls are crowded close together. Galls are also sometimes found on the new growth twig itself. The opening is a rather lip like slit usually transverse to the petiole. Fig. 48.

Collection data are as follows:—

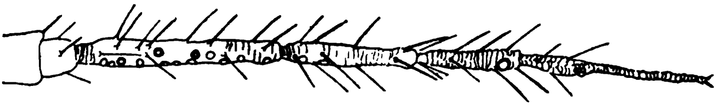
60-06, and 65-10, July 7 and 10, 1906. Irregular globular galls on petiole containing winged forms and pupæ.

64-06, July 10, 1906. Irregular globular galls on new growth twigs of *Populus.*

28-11, Orono Campus. *Populus deltoides* Marsh (var. Carolina poplar) July 12, 1911. Galls contained stem mother, small nymphs, pupæ and winged migrants.

Chaitophorus populicola Thomas. This well marked species does not seem to be confused with other American species either in our literature or collections. Common in Maine on Cottonwood, American Aspen (*P. tremuloides*) and Balsam Poplar (*P. balsamifera*).

Alate viviparous form. General color a varnished black. Antenna black with III paler. Sensoria as shown in figure 29. Abdomen black, hirsute with cornicles yellow. Wing veins black and heavily shadowed, shadow broader at tip of veins especially with the two discoidals where it broadens to a dark V. Fig. 46 K.



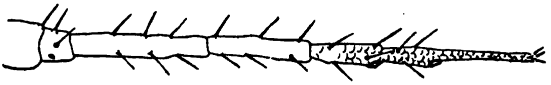


Fig. 29. *C. populicola.* Antenna of alate female.
Fig. 30. Antenna of apterous female.

Apterous viviparous form. Head and antenna black with III pale. Abdomen black dorsally and highly polished, ventral side paler and brownish. Cornicles light almost white. The progeny of these are reddish brown with a distinct yellowish λ, the stem of which extends to front of head, the fork coming on the abdomen and being much more distinct than the stem. Another yellow spot at caudal part of abdomen, and cornicles are very pale. Body mottled with black specks. Antenna brownish with III pale. Fig. 30. Legs brown.

Collection data as follows:—

47-04, Orono, June 23, 1904. Dark apterous females and nymphs on Aspen Poplar.

47-05, Veazie, Aug. 15, 1905. Balsam Poplar.

33-06, June 18, 1906. Both winged and apterous viviparous females on Balsam Poplar.

59-06, July 3, 1906. Both apterous and winged viviparous females and pupæ on Aspen Poplar.

93-06, August 3, 1906. Both apterous and winged viviparous females on Aspen Poplar.

13-08, June 19, 1908, Veazie. Winged and apterous viviparous females, pupæ and nymphs on leaves and tender shoots of Balsam Poplar.

39-08, Veazie, July 10, 1908. Winged viviparous females and nymphs on leaves and tender shoots of Balsam Poplar.

40-10, Veazie, June 29, 1910. Winged viviparous female and her progeny on ventral side of Balsam Poplar leaf.

41-10, Veazie, June 29, 1910. Winged and apterous females and nymphs on Aspen Poplar.

56-10, Orono, July 12, 1910. Winged and apterous females and nymphs on Balsam Poplar.

70-10, Veazie, July 21, 1910. On leaves and petioles. Apterous females very dark,—some entirely black except for a yellow mark on cephalic portion of abdomen and whitish yellow cornicles,—others yellowish brown as usual. Newly dropped nymphs orange yellow. Winged forms also present.

71-10, Veazie, July 21, 1910. On leaves and petioles of Aspen Poplar. Alate females and small dark apterous females.

5-11, Orono, July 14, 1911. On petioles and new growth twigs of cottonwood. Alate viviparous female.

96-12, Veazie, July 18, 1912. Apterous and alate females, on Balsam Poplar leaves and also in galls of *Pemphigus gravicornis.*

Chaitophorus delicata n. sp. A tiny species which I had not seen before and which appears to be undescribed was collected from the leaf of Aspen Poplar (*P. tremuloides*) by Mr. William C. Woods last summer.

The apterous females, nymphs and pupæ, were all a pellucid water white with a vivid green mark on prothorax, a transverse green stripe on first abdominal segment, and a green blotch in the region of the white cornicles more or less connecting them. Fig. 31 shows the relative length of the antennal joints.

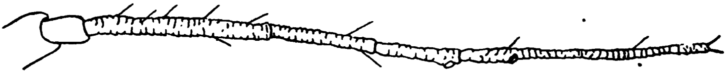


Fig. 31. *C. delicata.* Antenna of apterous female.

No winged forms were obtained.

Collection data as follows:—

104-12, Veazie, July 18, 1912. Leaf of Aspen Poplar. A small collection of apterous females, nymphs and pupæ.

119-12, Orono, July 29, 1912. A small collection from ventral leaf of Aspen Poplar. Apterous females, nymphs and one pupa.

Chaitophorus viminalis Monell? Until the life cycle of this species with careful detailed descriptions of the successive generations has been worked out by some one I refrain from definitely attributing Maine collections to either *viminalis* or *nigrae* as at present I am too much confused to contribute any aid to the situation. What I take to be *viminalis* has two successive generations of apterous forms which are so different

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in appearance that they might easily be mistaken for two distinct species and it would not be strange if this aphid has already been described under several names.

My color notes on collection 30-06, Veazie, June 15, 1906, *Salix* may be of interest in this connection. The apterous viviparous female had dorsal surface blackish with single well defined yellowish green streak extending from front of head to style,—streak very narrow through head but broadening in the central surface of body to an ovate space, narrowing again toward tip of abdomen. Cornicles yellow, style yellowish green, whole ventral surface greenish yellow. The apterous aphides that the form just described give birth to are uniform pale yellowish green with two vivid green longitudinal lines on the abdomen.

The alate viviparous females of this species present at the same date (June 15) have head and thorax black and abdomen black with greenish yellow lateral margin, cornicles dark, ventral abdomen greenish yellow. The wing (Fig. 46 E) is uniformily smoky dark with slender brown veins and brown stigma. For antennæ see Figs. 32 and 33.

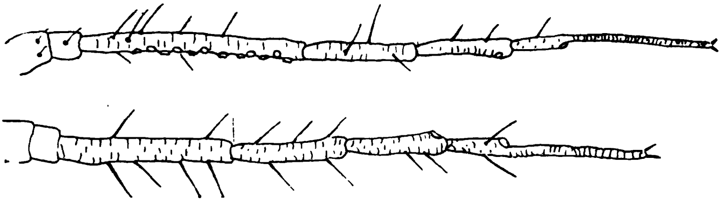


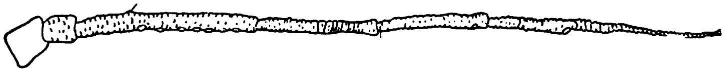
Fig. 32. *C. viminalis.* Antenna of alate female.
Fig. 33. Antenna of apterous female.

There are other species of *Chaitophorus* on *Salix* in Maine but my notes are not sufficient to record.

Aphis salicicola Thomas, I have taken only twice. It is characterized by long cylindrical cornicles, a style proportionately long, and the short branch of Media (Fig. 46 L). The relative length of the antennal segments are shown in Fig. 34. Antennal III has a single row of about seven rather faint sensoria. Fig. 35 shows the cornicle drawn to the same scale as the antenna.

36-04. Apterous and alate viviparous females collected from *Salix*, Orono, June 14, 1904.

88-12. Apterous viviparous females, *Salix*, Orono, July 16, 1912.



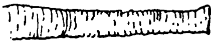


Fig. 34. *A. salicicola.* Antenna of alate female.

Fig. 35. Cornicle of same.

Aphis populifoliae Davis. Speckled Poplar Aphid. This remarkable species found usually on the upper surface of poplar leaves was described by Mr. Davis under the name of *Aphis populifoliae* (Fitch) in June, Econ. Ent. Vol. 3, 1910, p. 489.

The alate viviparous female has the following characters. Head black; no frontal tubercles; antenna with from about 20 to 30 sensoria on III, and few or none on IV relative length of joints shown in Fig. 36; eyes black; beak black, extends to between 2nd and 3rd coxæ; prothorax black, lateral tubercles prominent; shape and venation of wings as usual for *Macrosiphum*, Fig. 46 G, veins and stigma black; legs with femora black, tibiæ pale proximal 2-3 and black distal 1-3, tarsi black; abdomen black or reddish black with snow white pulverulent spots on dorsum arranged in transverse rows of one row per segment, venter slightly powdered; cornicles long cylindrical slightly swollen near base and black; style ensiform and upturned.

The apterous viviparous female is in general appearance black spotted with white. Head black, antenna (Fig. 38) black except proximal III which is very pale; sensoria present on III; eyes black; prothorax black with 2 white dorsal dots, tubercles present; thorax brownish black; legs with femora mostly dark proximally pale, tibiæ mostly pale, distally dark, tarsi black; abdomen brownish black with white pulverulent spots and venter pulverulent; cornicles long, black, cylindrical, slightly swollen near base. Fig. 39 shows cornicle drawn to the same scale as Fig. 38.

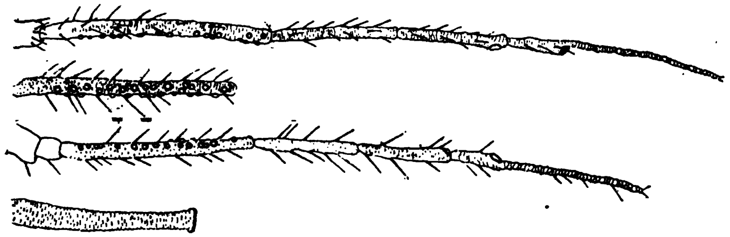


Fig. 36. *A. populifoliae.* Antenna of alate female. Fig. 37. Joint III of same from another individual. Fig. 38. Antenna of apterous female. Fig. 39. Cornicle of same.

Habitat of this species on new growth twigs but especially on dorsal surface of leaves causing a slight longitudinal curl upward. Found on *Populus balsamifera, P. tremuloides,* and certain other species of *Populus.*

Collection data: 58-06. One apterous viviparous female with progeny on dorsal leaf. Two alate viviparous females with progeny on dorsal leaves. *Populus balsamifera* and *P. tremuloides* July 3, 1906.

20-08. Apterous viviparous females and progeny. *Populus* sp. Orono, June 22, 1908.

36-08. A mass of this black and white species with a black and white larva of a lady beetle made one of the prettiest "coloration" schemes I have ever seen. *Populus* sp. terminal leaves and tender shoots. Orono, July 9, 1908.

70-08. Winged viviparous female and pupæ on balsam poplar (tender growth of water sprout). Orono, Aug. 25, 1908.

58-10. Apterous viviparous females and progeny on dorsal surface of leaves of *Populus balsamifera* causing a very slight upward curl of leaf. Orono, river bank, July 12, 1910.

77-10. Apterous and alate viviparous females, nymphs and pupæ on *P. balsamifera* on dorsal surface of leaves causing slight curl upward. Orono, river bank, July 23, 1910.

95-12. Apterous and alate viviparous females and nymphs on dorsal surface of leaves of balsam poplar turning the edges of edge and more or less crumple. Also present in galls of *Pemphigus gravicornis,* Veazie Sand Bank, July 18, 1912.

106-12. Alate and apterous viviparous females and nymphs on dorsal surface of leaves of balsam poplar turning the edges slightly upward. Veazie, July 18, 1912.

Macrosiphum laevigatae Essig. In 1910 a colony of *Macrosiphum* was collected on the campus here at Orono since described from California as *laevigatae*. They were found on the ventral side of the tender tip leaves of willows at the rear of campus heating plant. Only apterous viviparous females and nymphs were taken that season, collection 78-10, but July 16, 1912, winged forms were found on *Salix* at Orono, collection 87-12.

The apterous viviparous female has a light greenish yellow head; antennæ (Fig. 40) with I, II, and III except articulation pale, and IV-VI black, III with 3 to 5 inconspicuous sensoria near base; eyes black, thorax, abdomen almost white with greenish yellow tinge and with a vivid green longitudinal line extending from prothorax to the fifth or sixth segment of abdomen where it sometimes stops abruptly; cornicles longer than antennal III, concolorous at base and dusky at tip which is distinctly though irregularly reticulated for a distance equaling about one-ninth the length of cornicle, the basal eight-ninths being comparatively smooth (Fig. 42); style concolorous with abdomen. There is a minute lateral abdominal tubercle just cephalad the base of the cornicle.

The winged viviparous female has about 10 delicate sensoria on basal half of antennal III. Fig. 41, drawn to the same scale as Fig. 42.

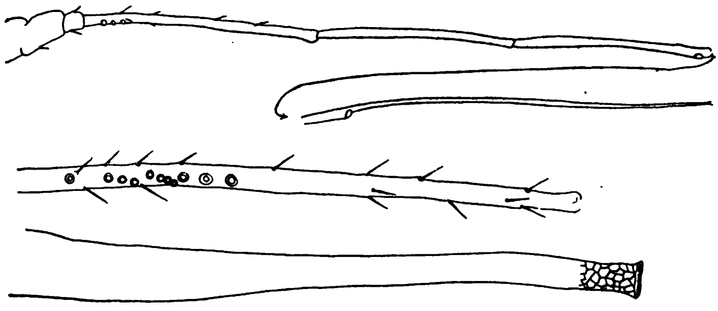


Fig. 40. *M. laevigatac.* Antenna of apterous female. Fig. 41. Joint III of antenna of alate female. Fig. 42. Cornicle of apterous female.

Melanoxantherium bicolor Oestlund. A species which I take to be *bicolor* is not uncommon here on Balsam Poplar.

Apterous viviparous female. Head reddish brown. Eyes black. Antenna with proximal part dingy yellow and distal part black. Spur much longer than basal VI. Prothorax and thorax reddish brown, lateral tubercles prominent. Fig. 44 A. Legs with femora dingy yellow and tibiæ and tarsi black. Abdomen dark mottled reddish brown with pale inconspicuous median dorsal line, lateral tubercles prominent. Cornicles light dingy yellow like femora and longer and more slender than in *smithiae*. (51-10). *Pupa* colored like the apterous female.

Alate viviparous female. Head reddish brown. Antenna (Fig. 43) with spur much longer than basal VI. Prothorax reddish brown, lateral tubercles prominent, Fig. 44 A. Thorax reddish brown. Wings with pale slender veins and light brown stigma. Legs with brownish yellow femora and tibiæ tipped with black, tarsi black. Abdomen reddish brown, cornicles light, dull brownish yellow. Fig. 45 A. Only a slight indication of a median dorsal line toward tip of abdomen. The young progeny of this form have a median grayish dorsal line the whole length of the body. (34-06).

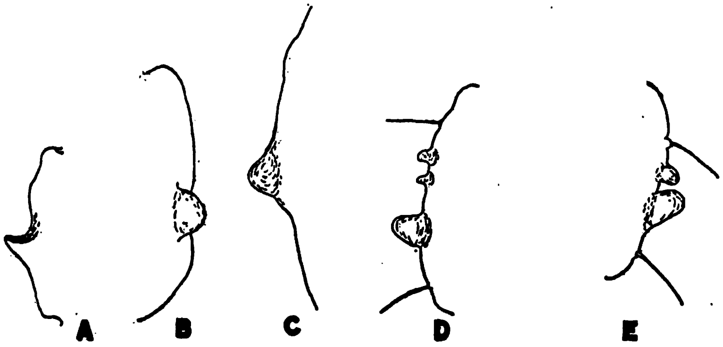


Fig. 44. *Melanoxantherium.* Prothoracic tubercles all drawn to the same scale. A, *bicolor,* apterous viviparous; B, *saliciti,* alate viviparous; C, *smithiae,* alate viviparous; D and E, *salicis,* apterous viviparous.

Collection data:—4-04 (in part). Orono, May 26, 1904. Winged specimens of both this species and *smithiae* were fairly abundant resting on the upper side of cultivated currant leaves.

They had probably merely alighted there as a resting place as no nymphs were present. The currants were not adjacent to willows, though willows were not far distant.

34-06, Veazie, June 19, 1906. Winged form on *Populus balsamifera.*

51-10, Veazie, July 7, 1910. Balsam Poplar. Apterous and alate females and pupæ.

Melanoxantherium salicti Harris. A species which I have taken for *salicti* was collected in Maine on willow in 1906. Head slaty black, not glistening, antenna black except at base. III with about 22 sensoria irregularly placed (Fig. 43, B.). Eyes black. Prothorax black, lateral tubercles present. Fig. 44, B. Thorax black with scutel lobe brownish, wings hyaline with pale brown veins and stigma the color of veins, legs with femora bright yellow, tibiae yellowish with dark distal tip, tarsi black. Abdomen black with bright yellow cornicles which are shaped much as in the foregoing species. (Fig. 45 B).

Predominating color slate-black with orange yellow legs and cornicles. There is the faintest suggestion of a light mid-dorsal line. (25-06). Orono, June 16, 1906. Willow twig.

Nymphs (half grown progeny of foregoing). Predominating color dark reddish brown with conspicuous median dorsal line of grayish white extending from front of head to cauda. Ventral surface slightly powdery gray. Antenna light, clear, with distal end dark. Legs with femora light clear, slightly yellowish, tibiæ dusky, and tarsi black. Cornicles yellow. 26-06. Orono, June 16, 1906. Willow twig.

Melanoxantherium smithiae Monell. A dusky reddish species with hyaline wings, and pale pulverulent longitudinal median line on abdomen, cornicles orange, shorter and more bulging than in the three species preceding, accords with named specimens of *smithiae* kindly given me by Mr. Monell. Figs. 43 C, 44 C and 45C, D. On *Populus,* migrating to *Salix* early in June.

Collection data for this species are as follows:

4-04 (in part). Mixed collection of *bicolor* and *smithiae.* Winged forms resting on cultivated currant (probably alighted there temporarily only). Twelve taken in one hour. No progeny present. May 26, 1904. Orono.

15-04. Winged females. Willow. May 26, 1904, Orono.

66-04 and 67-04. Heavy infestation of winged and apterous females on willow in front of Experiment Station Building Sept. 9, 1904. This species proved such an annoyance to people using the building that the willows were removed.

6-07. Specimens received from Caribou, Maine, June 17, 1907, with the complaint that "they cover a limb and suck the bark until it is dead and peels off." On Carolina Poplars and Aspen trees.

64-10. Apterous viviparous females and nymphs on *Salix*, near Campus Greenhouse, new growth twig, Orono, July 18-25, 1910.

95-10. Apterous viviparous females and nymphs numerous along *Salix* stem. Orono, Aug. 18, 1910.

126-10. Winged and apterous viviparous females numerous on same willows from which 64-10 were collected. Sept. 15, 1910.

26-13. Orono *Populus*. June 2, 1913. Pupæ, and migrants ready for flight.

35-13. Orono, June 5, 1913. *Salix*. Migrants occurring singly with young.

Melanoxantherium antennatum n. sp. This remarkable species I have not met since 1908, and only the apterous oviparous females were seen at that time. However, this form is so distinctive it seems unnecessary to wait longer for the winged forms before presenting a brief description.

The apterous oviparous female has a blackish head with black eyes; antenna blackish and with but 4 joints, III with single terminal circular sensorium; (Fig. 43 D) prothorax greenish brown; tubercle lacking or inconspicuous; entire leg black; abdomen hirsute; incrassate clavate cornicles black upon a yellow spot; (Fig. 45 E) dorsal surface of body with a general dark greenish brown coat or blackish; ventral surface greenish yellow. Ventro-lateral margin of abdomen with the appearance of a longitudinal roll.

103-08. Apterous oviparous females and eggs received from E. No. Yarmouth, Maine, Oct. 31, 1908, with the statement "we find a great many of these insects on and in a pump which stands beneath an old willow."

104-08. Apterous oviparous females received from Cherryfield, Maine, Nov. 4, 1908.

Melanoxantherium salicis Linn. This black bodied aphid with conspicuous white spots, brilliant cornicles and heavily veined wings is a striking contrast to the allied but more subdued species of this genus.

Alate viviparous female. Head blackish; antenna (Fig. 43 E) with I, II, III brown, others blackish, III with about 14 sensoria in irregular row, base and spur of VI subequal; eyes black; prothorax blackish with prominent lateral tubercle; thorax with lobes all uniform black; wings with very heavy black veins, anal vein heaviest; legs with femora and tibiæ brown with points dark, tarsi black; abdomen greenish or brownish black with white median line composed of dots and with 4 white spots cephalad the cornicles in a row bordered by smaller ones and a large white spot at base caudad of cornicle; cornicles brilliant orange, long large bulging and with very little flare at opening, about as in the apterous form.

The young progeny of the alate viviparous females are dull greenish with bright orange cornicles and white markings arranged as in the parent.

Apterous viviparous female. The antenna (Fig. 43 F) with sensoria on III, but fewer than in the alate form. The cornicles are bright orange, long, large, bulging, constricted at tip with a very slight flare. (Fig. 45 F). The lateral tubercles of prothorax and abdomen are very large and conspicuous. In Maine collections the number and arrangement of those on the prothorax seem subject to variation. There is always one large prominent one but one or two others may be present. (Fig. 44 D and 44 E).

Collection data: 49-06. June 28, 1906. Alate viviparous females and nymphs on *Salix* along branches more than 1-4 inch in diameter.

8-08, Orono, June 16, 1908, on trunks and branches of *Salix* in gregarious colonies.

12-10. May 16, 1910. Gregarious along stem of *Salix*, Orono. Apterous viviparous females just mature not yet with progeny. Body black, cornicles bright orange.

16-10. May 18, 1910. Nymphs. First instar with 4-jointed antennæ and beak reaching beyond tip of abdomen. Second instar with 4-jointed antenna and beak extending beyond 3rd coxa. Third instar with 5-jointed antenna. June 6, winged forms rapidly developing from colonies near base of main willow trunk.

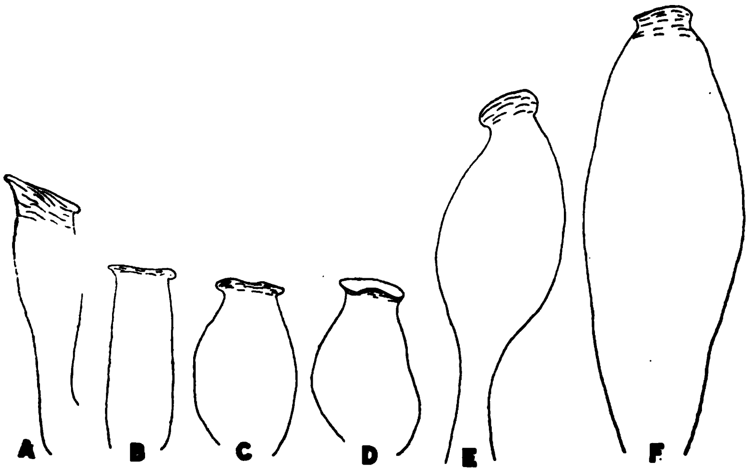


Fig. 45. *Melanoxantherium* cornicles all drawn to the same scale. A, *bicolor,* alate viviparous; B, *salicti,* alate viviparous; C and D, *smithiae,* alate and apterous viviparous; E, *antennatum* apterous oviparous; F, *salicis* apterous viviparous.

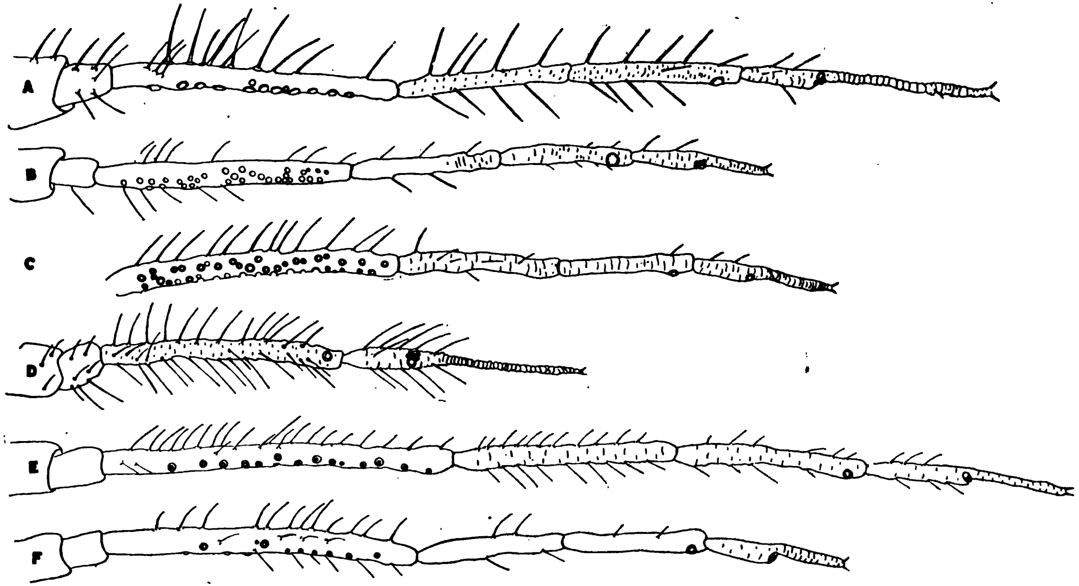


Fig. 43. Antennæ of *Melanoxantherium*, all drawn to the same scale. A, *bicolor*, alate viviparous; B, *salicti*, alate viviparous; C, *smithiae*, alate viviparous; D, *antennatum*, apterous oviparous; E, *salicis*, alate. viviparous; F. *salicis*. apterous viviparous.

APHID CONTROL.

Shade or ornamental trees can be protected frequently from serious aphid attacks by keeping watch from year to year. This is especially desirable while trees are young. Later it is more difficult, but the damage is not usually as serious on large well established trees.

From small or isolated trees the galls of gall forming species can sometimes be collected by hand before the aphides leave them. thus lessening the trouble in that vicinity for another year.

Species inhabiting the trunk of large branches can be destroyed in great numbers by using a brush dipped in any of the spray solutions ordinarily used for aphides.

Tips of branches bearing leaves which have been curled by aphides can be dipped into a tobacco decoction long enough for the solution to penetrate. Such a method as this is of course only applicable for a few treasured plants or small trees.

In recent years tobacco extracts have rapidly taken the place of other sprays for aphides, and well informed apple growers are using them almost to the exclusion of other insecticides. It should be remembered that this is a contact insecticide and kills only the insects actually touched. It is, therefore, necessary to be very thorough in the spraying

Formula—Tobacco Decoction.

Tobacco stems or tobacco dust................	2 pounds.
Water	4 gallons.

Put the tobacco in the water, enough to cover, which may be either cold or hot. Place over the fire and when the water has reached the boiling point, remove some of the fire and allow the water to simply *simmer* for fully one hour, when the liquid is ready to be drained off, diluted to the above proportions and applied. Boiling violently drives off the nicotine.

If whole-leaf tobacco is used, prepare as above, using one pound of tobacco to each four gallons of water.

No lime or other alkaline substance should be added to the tobacco *while cooking*. Apply at once or within a few days after making, if possible.

Certain reliable extracts such as *"Black Leaf," "Black Leaf 40,"* and *"Nikoteen"* are on the market and can be secured through local druggists. The Black Leaf preparations are manufactured by *The Kentucky Tobacco Product Company,* Louisville, Ky., and are carried by the Collins Hardware Company, 97 Friend St., Boston, Mass. *Nikoteen* is manufactured by The Nicotine Manufacturing Company, St. Louis, Mo., and can be secured from Joseph Brick & Sons, 47-54 N. Market St., Boston, Mass.

Directions for use come with the products. There is nothing to do in the preparation of these extracts except to stir the contents of the can before pouring out any quantity for dilution. In most cases one gallon of the *Black Leaf* will be found sufficient for each seventy gallons of water. But if in the treatment of any louse this does not seem sufficient it may be used in proportion of one gallon to sixty or sixty-five gallons of water. Careful sprayers have usually succeeded in killing plant lice with this preparation in the proportion of one gallon to each one hundred gallons of water. Thoroughness of application is of as much importance as the strength of the material used.

Nikoteen is a more concentrated abstract, 1 part being used with from 400 to 600 parts of water.

Black Leaf 40 is a concentrated solution of nicotine-sulphate and is widely and successfully used in large western orchards, at the rate of 1 part to 700 or 800 parts of water.

It is the common practice to add soap,—whale oil soap or good laundry soap at the rate of 2 bars to 50 gallons. This is to lessen the formation of drops, causing the spray to cover surfaces more in the form of a thin film.

Better success is obtained by some by using a little lime instead of soap, the inert solid in suspension aiding the extract to "wet" and "stick" to the bodies of the aphids. For this purpose 1 pound of stone lime, slaked and strained into 50 gallons of tobacco extract as prepared for application, is sufficient.

When other plant enemies besides aphids are present "Combination sprays" are frequently successfully applied. Self-boiled lime-sulphur (8-8-50 cold) may be used adding 1-70 of its volume of *Black Leaf*. On the same basis *Black Leaf* may be combined with Bordeaux (5-5-50) or with lead arsenate or with both together when foes combine against one kind of plant.

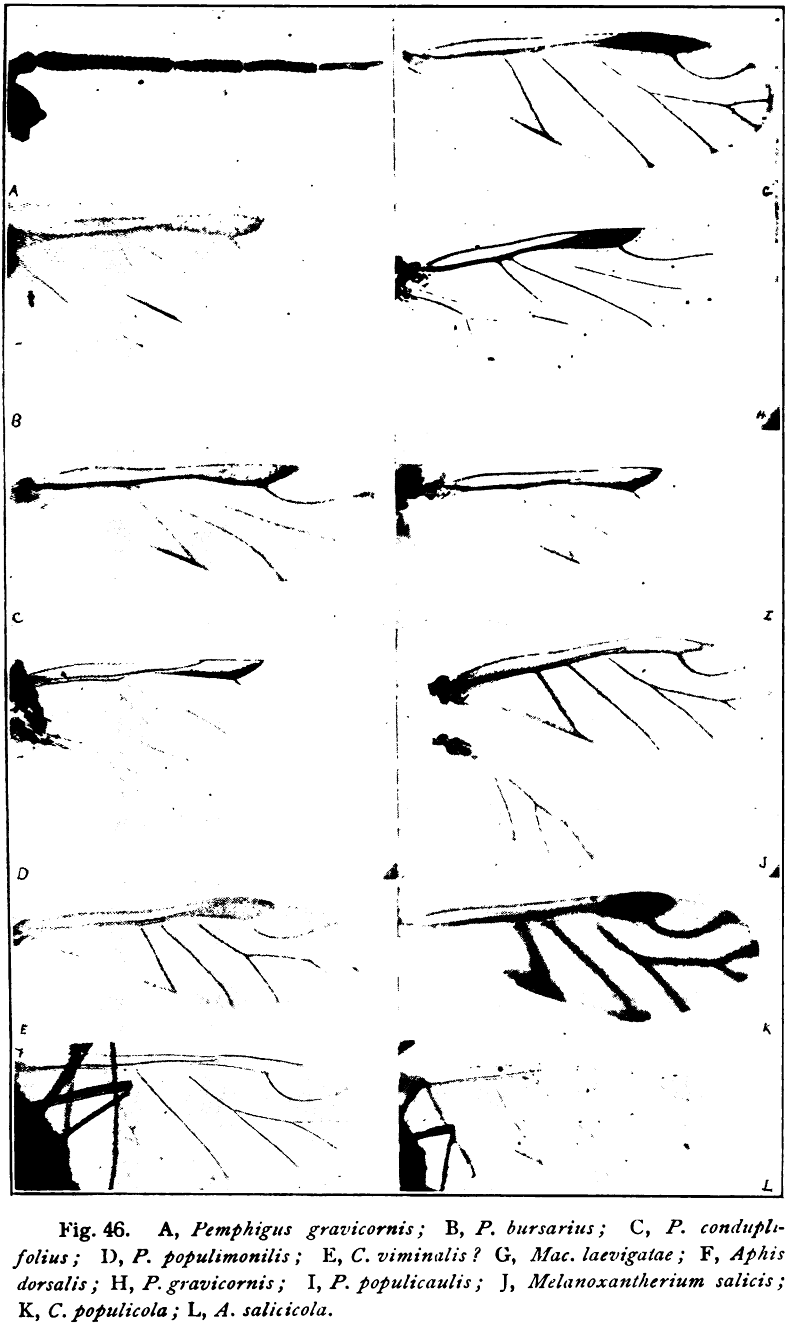
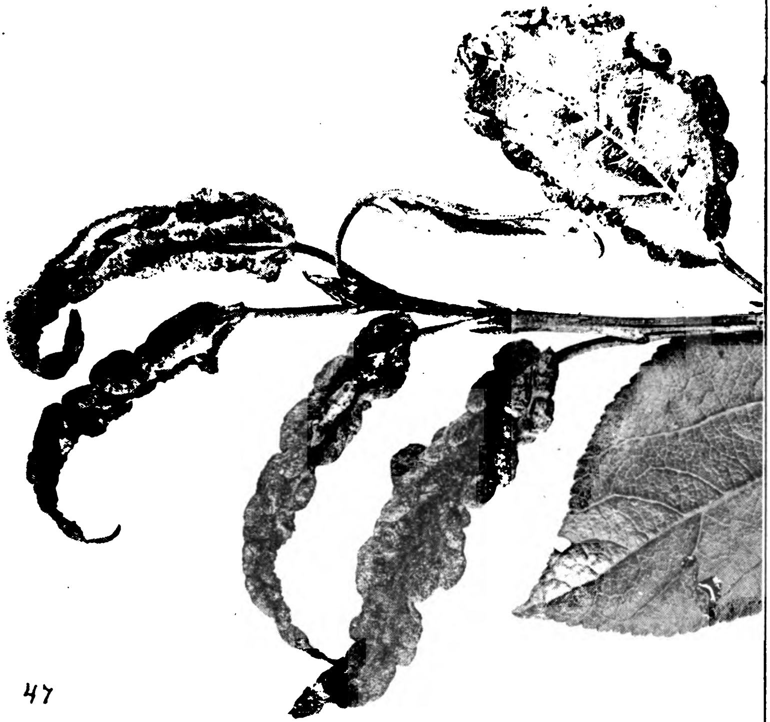


Fig. 46. A, *Pemphigus gravicornis;* B, *P. bursarius;* C, *P. conduplifolius;* D, *P. populimonilis;* E, *C. viminalis?* G, *Mac. laevigatae;* F, *Aphis dorsalis;* H, *P. gravicornis;* I, *P. populicaulis;* J, *Melanoxantherium salicis;* K, *C. populicola;* L, *A. salicicola.*



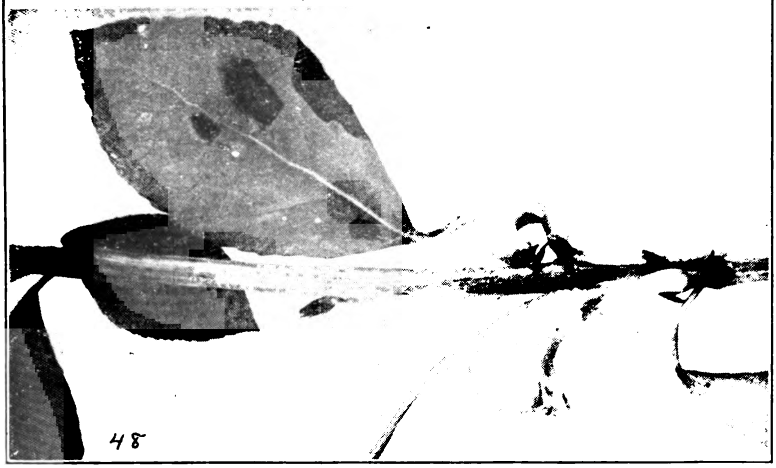
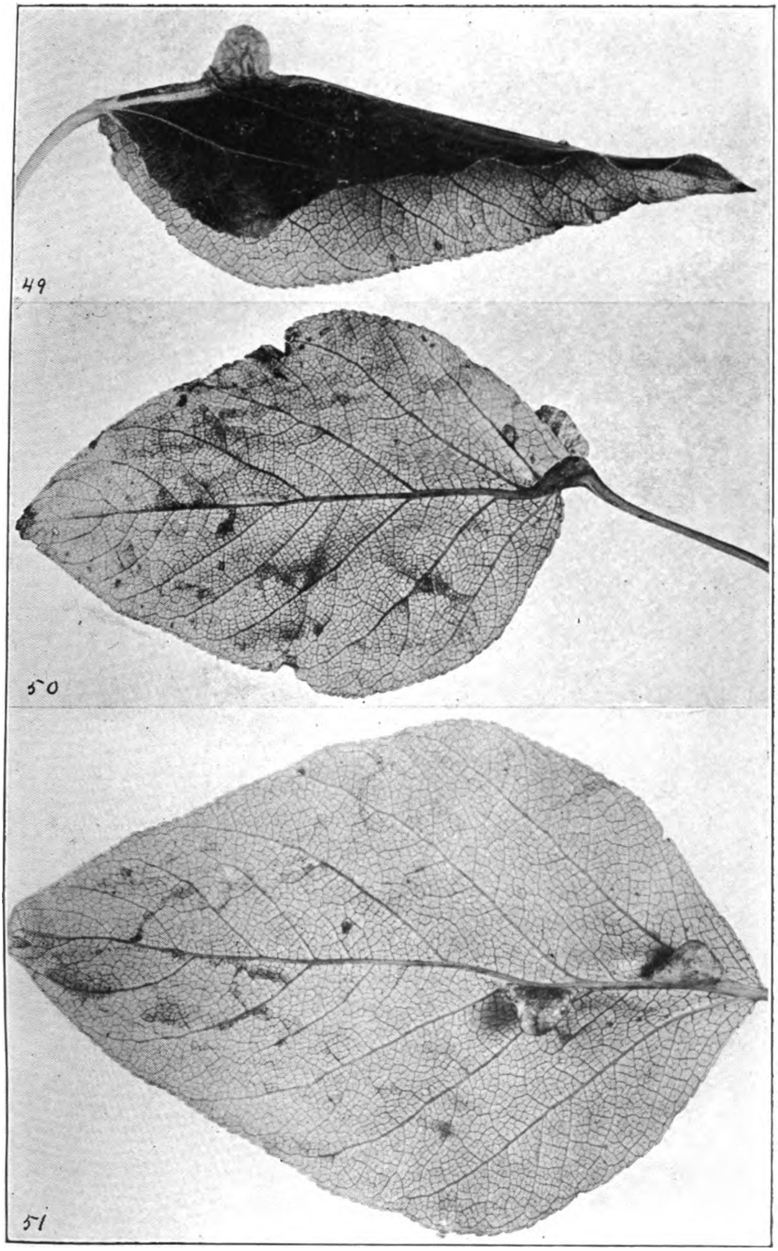
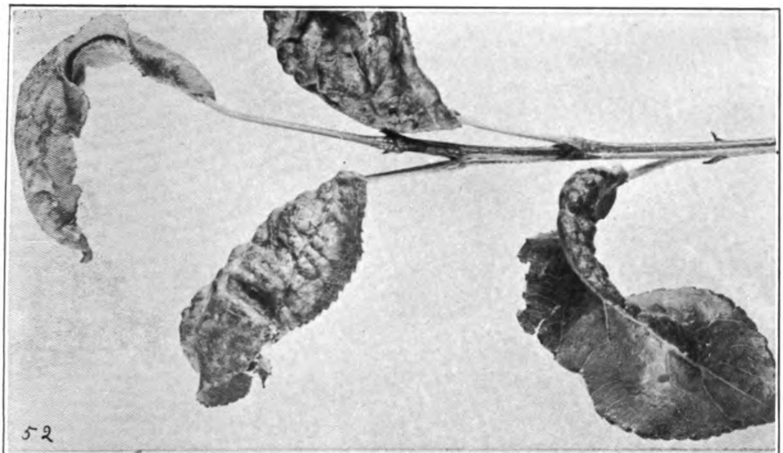


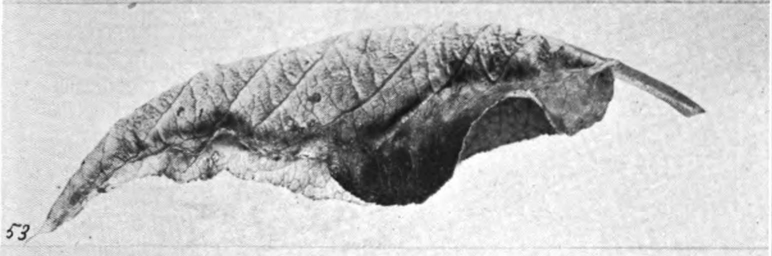
Fig. 47. *P. populimonilis.* Galls collected at Veazie, Maine, July 27, 1909.

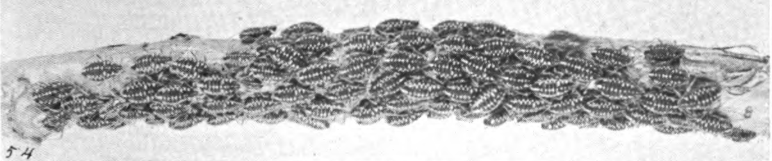
Fig. 48. *P. bursarius.* Galls collected at Orono, July 12, 1911.



Figs. 49-51. Galls of *Pemphigus populicaulis.*







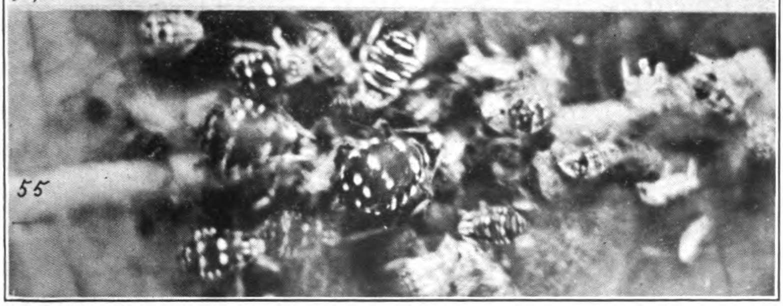


Fig. 52. *P. populiconduplifolius.* Galls collected at Orono, July 15, 1912. **Fig. 53.** *P. gravicornis.* Galls collected at Orono, July 7, 1911.

Fig. 54. *Melanoxantherium salicis.* Collection made at Orono, May 16, 1910. **Fig. 55.** *Aphis populifoliae.* Collection made at Veazie, July 18, 1912.

FOOD PLANT CATALOGUE OF THE APHIDAE OF THE WORLD.

PART II.*

EDITH M. PATCH.

SALICACEAE. WILLOW FAMILY.

POPULUS. Poplar. Aspen.

P. alba L. (canescens). White Poplar, Silver-leaved Poplar.
- *Chaitophorus populi* (Linn.) Pass. (Myzaegirus Amyot), (Arctaphis populi Walker). Buckton, 2, p. 142.
- *Cladobius populae* Kalt. (Aphis) Macchiati, 1883, p. 260.
- *Guercioja populi* Del Guercio. Mordwilko, 1908, p. 361 (9).
- *Lachnus longirostris* Fab? Passerini, 1860, p. 38.
- *Lachnus longirostris* Fab. Kaltenbach, 1874, p. 92.
- *Lachnus longirostris* Pass. Kaltenbach, 1874, p. 562.
- *Pachypappa vesicalis* Koch. Cholodkovsky, 1901, p. 293.
- *Schizoneura tremulae* DeGeer. Kaltenbach, 1874, p. 561.

P. angustifolia James (laevigata).
- *Chaitophorus populicola* Thomas. Hunter, 1901, p. 88.
- *Pemphigus populi-monilis* Riley. Cowen, 1895, p. 116.

P. balsamifera L. Balsam Poplar, Tacamahac (1911).
- *Aphis populifoliae* Davis, 1910. Patch, 1913, Bul. 213, p. 82.
- *Chaitophorus populicola* Thomas. Patch, 1913, Bul. 213, p. 78.
- *Melanoxantherium bicolor* Oestlund. Patch, 1913, Bul. 213, p. 85.
- *Pemphigus balsamiferae* Williams. Williams, 1910 (1911), p. 8.
- *Pemphigus gravicornis* Patch. Patch, 1913, Bul. 213, p. 75.
- *Pemphigus popularius* Fitch. Jackson, 1908, p. 191.
- *Pemphigus populicaulis* Fitch. Jackson, 1908, p. 193.
- *Pemphigus populiconduplifolius* Cowen. Gillette, 1909a, p. 355. Patch, 1913, Bul. 213, p. 76.
- *Pemphigus populiglobuli* Fitch. Jackson, 1908, p. 197.
- *Pemphigus populimonilis* Riley. Essig, 1912, p. 707. Patch, 1913, Bul. 213, p. 73.
- *Pemphigus populiramulorum* Riley. Jackson, 1908, p. 209.
- *Pemphigus populitransversus* Riley. Jackson, 1908, p. 207.
- *Pemphigus populivenae* Fitch. Jackson, 1908, p. 195.
- *Stagona vesicalis* Rudow. Rudow, 1875, p. 249.

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* Papers from the Maine Agricultural Experiment Station: Entomology No. 66. For Part I see Bulletin 202.

P. berolinensis.

Pemphigus bursarius L. (lactucarius Pass) (pyriformis Licht.) Tullgren, 1909, p. 122.

P. canadensis.

Pemphigus filaginis Boyer. (gnaphalii Kalt) (prociphilus gnaphalii Koch) (Pachypappa marsupialis Koch) (ovato-oblongus Kessler). Tullgren, 1909, p. 136.

P. candicans Ait. Balm-of-Gilead.

Aphis candicans Fitch. Monell, 1879, p. 26.
Chaitophorus candicans Thomas. Hunter, 1901, p. 87.
Melanoxanthus salicis Linn. Cowen, 1895, p. 117.

P. deltoides Marsh. (monilifera) (angulata) Cotton-wood, Necklace Poplar.

Arctaphis sp. Cooley, 1912, p. 89. "New Aphis of Cottonwoods."
Chaitophorus populicola Thomas. 1879, p. 104.
Chaitophorus populifolia Fitch (stevensis Sanborn). Sanborn, 1904, p. 36 and 1906, p. 225.
Chaitophorus populifoliae (Fitch). Hunter, 1901, p. 88.
Melanoxantherium salicti Harris. Weed, 1891, p. 290.
Pemphigus betae Doane. Gillette, 1912, (24th Rept. Exp. Sta.) p. 28. "On Cottonwood."
Pemphigus bursarius Linn? Patch, 1913, Bul. 213, p. 78.
Pemphigus oestlundi Cockerell, 1906, p. 34.
Pemphigus populicaulis Fitch. Sanborn, 1904, p. 20.
Pemphigus populicaulis Fitch. Jackson, 1908, p. 193.
Pemphigus populiconduplifolius Cowen. Jackson, 1908, p. 217.
Pemphigus populitransversus Riley. Sanborn, 1904, p. 22.
Pemphigus populitransversus Riley. Jackson, 1908, p. 207.
Pemphigus pseudobyrsa Walsh. Jackson, 1908, p. 199.
Phylloxera popularia Pergande. Pergande, 1904b, p. 266.
(In galls of Pemphigus transversus Riley).
Phylloxera prolifera Oestlund. Oestlund, 1887, p. 17. (In galls of Pemphigus populicaulis Fitch).

P. Fremonti S. Wats.

Chaitophorus populicola Thomas. Williams, 1891, p. 9.
Melanoxanthus salicti (Harris). Williams, 1891, p. 9.
Mordwilkoja oestlundi (Cockerell) (Pemphigus vagabundus Walsh) Davis, 1911, p. 4.
Pemphigus populicaulis Fitch. Williams, 1891, p. 9.
Pemphigus populimonilis Riley. Davidson, 1910, p. 374.
Pemphigus populiramulorum Riley. Jackson, 1908, p. 209.
Pemphigus populitransversus Riley. Williams, 1891, p. 9.
Pemphigus pseudobyrsa (Walsh). Williams, 1891, p. 9.
Phylloxera prolifera Oestlund. Williams, 1891, p. 9.
Thomasia populifoliae (Fitch). Essig, 1912a, p. 716.

P. grandidentata Michx. Large-toothed Aspen.

Aphis populifoliae Fitch. Thomas, 1879, p. 102.
Aphis (Dactynus) populus-grandidentata Raf. Rafinesque, 1818.

Chaitophorus populi (Linn). Hunter, 1901, p. 88.
Chaitophorus populifoliae (Fitch) "= C. populi (Linn.) ?" Oestlund, 1887, p. 39.

P. nigra L. Black Poplar.
Anuraphis populi Del Guercio. Del Guercio, 1909 (1910). Redia VII, p. 298.
Aphis populi L. Kaltenbach, 1874, p. 561.
Chaitophorus leucomelas Koch. Passerini, 1863, p. 58.
Chaitophorus leucomelas Koch., Pass. Buckton, 2, p. 135.
Chaitophorus lyratus Ferrari. Del Guercio, 1900, p. 119.
Chaitophorus nassonowi Mordwilko. Mordwilko, 1899, p. 410.
Chaitophorus populi (Linn) Pass. (Myzaegirus Amyot) (Arctaphis populi Walker). Buckton, 2, p. 142.
Chaitophorus versicolor Koch (Aphis populi var. Kalt) Ferrari, 1872, p. 76.
Lachnus viminalis Boyer. (Aphis). Ferrari, 1872, p. 80.
Pemphigus affinis Kalt. (Thecabius populneus Koch). Passerini, 1863, p. 74.
Pemphigus bursarius (L.) Kalt. Kaltenbach, 1874, p. 561.
Pemphigus bursarius Hartig. (Eriosoma populi Mosley) (Aphioides bursaria Rondani). Buckton, 3, p. 118.
Pemphigus filaginis Boyer (gnaphalii Kalt.) (Prociphilus gnaphalii Koch) (Pachypappa marsupialis Koch). (ovato-oblongus Kessler). Tullgren, 1909, p. 136.
Pemphigus spirothecae Koch (affinis Koch) (Puceron de peuplier Reaumur). Buckton, 3, p. 122.
Pemphigus spyrothecae Pass. Passerini, 1860, p. 39.
Pemphigus tortuosus Rudow. Rudow, 1875, p. 248.
Pemphigus vesicarius Pass. Passerini, 1863, p. 76.
Stomaphis bobretzkyi Mordwilko. Mordwilko, 1899, p. 411.
Stomaphis longirostris (Fab.). Del Guercio, 1907 (1908) Redia V, p. 344.
Thecabius populneus Koch. Koch, p. 295.
Thecabius populneus Koch. Kaltenbach, 1874, p. 562.

P. pyramidalis Salisb. (italica Duroi) (dilatata), Lombardy Poplar.
Chaitophorus leucomelas Koch. Kessler, 1882, p. 37.
Chaitophorus nassonowi Mordwilko. Mordwilko, 1899, p. 410.
Chaitophorus populeus (Kalt.) (Lachnus punctatus Burm?) (Cladobius populeus Koch). Buckton, 2, p. 137.
Chaitophorus populi (Linn). Pass. (Myzaegirus Amyot) (Arctaphis populi Walker). Buckton, 2, p. 142.
Cladobius populea Kalt. (Aphis.) Ferrari, 1872, p. 76.
Drepanosiphum smaragdinum Koch. Koch, p. 205.
Drepanosiphum (Aphis) tiliae Koch. Kaltenbach, 1874, p. 561.
Pemphigus affinis Kalt. Kaltenbach, 1874, p. 561.
Pemphigus bursarius Linn. Reaum (Aphis). Ferrari, 1872, p. 83.
Pemphigus bursarius Hartig (Eriosoma populi Mosley) (Aphioides bursaria Rondani). Buckton, 3, p. 118.

Pemphigus filaginis Boy de Fonsc. (gnaphalii Kalt.) (Prociphilus gnaphalii Koch.) (Pachypappa marsupialis Koch) (ovato-oblongus Kessler). Tullgren, 1909, p. 136.
Pemphigus glandiformis Rudow. Rudow, 1875, p. 247.
Pemphigus populicaulis Fitch. Jackson, 1908, p. 193.
Pemphigus protospirae Licht. Tullgren, 1909, p. 155.
Pemphigus spirothecae Pass. (affinis Koch). Tullgren, 1909, p. 161.

P. tremula L.

Aphis populi tremulae Ascanius. Hagen, p. 449.
Asiphum populi (Fab.) Koch. Koch, p. 246.
Asiphum tremulae DG. Tullgren, 1909, p. 66.
Chaitophorus populi (Linn.) Pass. (Myzaegirus Amyot) (Arctaphis populi Walker). Buckton, 2, p. 142.
Chaitophorus populi (Linn.) (Ch. tremulae Koch). Koch, p. 9.
Chaitophorus versicolor Koch. Passerini Flora.
Pachypappa lactea Tull. Tullgren, 1909, p. 72.

P. tremuloides Michx. (trepida). American aspen.

Aphis populifoliae Davis, 1910. Patch, 1913, Bul. 213, p. 82.
Aphis (Dactynus) populus-trepida Raf. Rafinesque, 1818.
Chaitophorus bruneri Williams. Williams, 1910, (1911), p. 26.
Chaitophorus delicata Patch. Patch, 1913, Bul. 213, p. 80.
Chaitophorus populicola Thomas. Gillette, 1909a, p. 388. Patch, 1913, Bul. 213, p. 78.
Cladobius beulahensis Cockerell. Cockerell, 1904, p. 263.
Pemphigus populicaulis Fitch. Hunter, 1901, p. 78.
Pemphigus? rileyi Stebbins. Stebbins, 1910, p. 9.

P. trichocarpa Torr. & Gray.

Chaitophorus populicola Thos. (?). Essig, 1909, p. 98.
Chaitophorus salicicola Essig. Essig, 1911b, p. 534.
Eichochaitophorus populifolii Essig. Essig, 1912a, p. 715.
Pemphigus populicaulis Fitch. Essig, 1912a, p. 712.
Pemphigus populimonilis Riley. Gillette, 1909a, p. 356.
Pemphigus populitransversus Riley. Davidson, 1910, p. 372.

P. sp.

Aphis populi-albae Boyer. Lichtenstein, La Flore.
Byrsocrypta vagabunda Walsh. Walsh, 1862, p. 306. (migrants "on various forest trees").
Chaitophorus albus Mordwilko. Mordwilko, 1899 (1901), p. 410.
Chaitophorus populifoliae Fitch. Davidson, 1910, p. 375.
Cladobius longirostris Mordwilko. Mordwilko, 1899, (1901), p. 414.
Cladobius rufulus Davidson. Davidson, 1910, p. 375.
Lachnus longistigma Monell. Sanborn, 1904, p. 31.
Pemphigus borealis Tullgren. Tullgren, 1909, p. 146.
Pemphigus immunis Buckton. Buckton, 1896, p. 51.
Pemphigus infaustus Ferrari. Lichtenstein, 1885 ("var. de P. spirothecae Pass.").

Pemphigus lichtensteini Tull. Tullgren 1909, p. 151.
Pemphigus napaeus Buckton. Buckton, 1896, p. 50.
Pemphigus oestlundi Cockerell. (P. vagabundus (Walsh) of authors). Oestlund, 1887, p. 22. Cockerell, 1906, p. 34.
Pemphigus populi Courchet. Courchet, 1881, p. 46.
Pemphigus populicaulis Fitch (betae Doane?). Clarke, 1903, p. 248.
Pemphigus spiriformis Licht. Zoölogical Record, 1886, p. 319 (misprint for pyriformis).
Pemphigus tortuosus Rudow. Lichtenstein, La Flore.
Pemphigus varsoviensis Mordwilko. Mordwilko, 1899, p. 411.
Schizoneura passerinii Signoret. Lichtenstein, La Flore.
Schizoneura populi Gillette. Gillette, 1901, p. 1.
Thecabius (*Pemphigus*) *affinis* Kalt. (ranunculi Kalt.). Tullgren, 1909, p. 110.

SALIX. Willow.

S. acuminata.
Lachnus viminalis (Boyer) Pass. (salicis Shaw?) (salicis Curtis?) (saligna Walker). Buckton, 3, p. 57.

S. alba L. (vitellina) White Willow.
Aphis populea Kalt. (Lachnus punctatus Burmeister). Kaltenbach, 1843, p. 117.
Aphis populea Kalt. Kaltenbach, 1874, p. 561.
Aphis salicis Linn. Kaltenbach, 1874, p. 586.
Chaitophorus saliceti Schrank (Aphis). Macchiati, 1883, p. 261.
Chaitophorus salicti Schrank (Aphis). Ferrari, 1872, p. 77.
Chaitophorus smitheae Monell. Monell, 1879, p. 32.
Chaitophorus viminalis Monell (?). Weed, 1888, p. 133.
Chaitophorus vitellinae Schrank (Aphis). Ferrari, 1872, p. 76.
Cladobius populae Kalt (Aphis). Macchiati, 1883, p. 260.
Cladobius steinheili Mordwilko. Mordwilko, 1899, p. 350. (? on Salix alba).
Lachnus longirostris Fab? (Aphis). Ferrari, 1872, p. 81.
Lachnus longirostris Fab. Kaltenbach, 1874, p. 92.
Lachnus longirostris Pass. Kaltenbach, 1874, p. 562.
Lachnus viminalis Boyer. Kaltenbach, 1874, p. 585. Del Guercio, 1907 (1908). Redia V, p. 345.
Melanoxanthus salicis (Linn.). Williams, 1891, p. 27.
Melanoxanthus smithiae Monell. Williams, 1891, p. 27.
Myzus ribis Linn. et auct (Aphis). Ferrari, 1872, p. 62.
Siphocoryne capreae (Fab.) Pass. (pastinacae L.) (A. aegopodii Scop) (R. capreae Koch) (R. cicutae Koch) (A umbellatarum Koch). Passerini, 1863, p. 52.
Stomaphis longirostris (Fab.) (Aphis Fab.) (Phylloxera Boyer) (Lachnus Passerini) Del Guercio, 1907 (1908) Redia V, pp. 259, 344.

S. amygdaloides Anders. Peach-leaved Willow.
Aphis salicicola (Thomas). Cowen, 1895, p. 121.

S. babylonica L. (annularis) Weeping Willow.
Aphis capreae Fab. (A. aegopodii Scop.). Kaltenbach, 1843, p. 109.
Aphis saliceti Kalt. Passerini, 1863, p. 37.
Aphis vitellinae Schrank. Kaltenbach, 1874, p. 585.
Chaitophorus viminalis Monell (?). Weed, 1888, p. 133.
Rhopalosiphum salicis Monell. Monell, 1879, p. 27.

S. laevigata Bebb.
Chaitophorus salicicola Essig. Essig, 1911b, p. 534.
Fullawaya saliciradicis Essig. Essig, 1912a, p. 716.
Macrosiphum laevigatae Essig. Essig, 1911b, p. 549.
Micrella monelli Essig. Essig, 1912a, p. 715.
Symdobius salicicorticis Essig. Essig, 1912a, p. 715.

S. lapponum L.
Chaetophorus salicivorus Passerini. Schouteden, 1906a, p. 213.

S. lasiolepis Benth.
Micrella monelli Essig. Essig, 1912a, p. 715.

S. longifolia M. (interior) Sand Bar Willow.
Chaitophorus nigrae Oestlund. Cowen, 1895, p. 117.
Melanoxanthus salicis (Linn.). Williams, 1891, p. 27.

S. lucida Muhl. Shining Willow.
Chaitophorus viminalis Monell (?). Weed, 1888, p. 133.
Melanoxanthus salicis (Linn.). Williams, 1891, p. 27.
Siphocoryne (*Rhopalosiphum*) *salicis* (Monell). Oestlund, 1887, p. 70.

S. macrostachya Nutt.
Symdobius macrostachyae Essig. Essig, 1912a, p. 715.
Thomasia crucis Essig. Essig, 1912a, p. 716.

S. nigra Marsh. Black Willow.
Chaitophorus nigrae Oestlund. Oestlund, 1887, p. 40.
Rhopalosiphum salicis Monell. Monell, 1879, p. 27.

S. nigricans Sm.
Chaitophorus capreae Koch. Buckton, 2, p. 136.
Chaitophorus salicti (Schrank) Pass. Passerini, 1863, p. 60.
Cladobius populea (Kalt.) Koch. Passerini, 1863, p. 56.

S purpurea L. Purple Willow.
Chaitophorus salicivora Walker? Passerini, 1860, p. 37.
Chaitophorus salicivora Pass. (salicivora Walker?) Passerini, 1863, p. 58.
Lachnus viminalis Boyer. Kaltenbach, 1874, p. 585.

S repens L.
Chaitophorus hypogeus Del Guercio. Schouteden, 1906, p. 213.

S caprea L.
Aphis alterna Walker. Walker, 1849c, p. 43.
Aphis capreae Fab. (A. aegopodii Scop.) Kaltenbach, 1843, p. 109.

Aphis populea Kalt. (Lachnus punctatus Burmeister). Kaltenbach, 1843, p. 117.
Aphis saliceti Kalt. Buckton, 2, p. 53.
Aphis salicis Linn. Kaltenbach, 1874, p. 586.
Aphis secunda Walker. Walker, 1849c, p. 44.
Chaitophorus capreae Koch. Buckton, 2, p. 137.
Chaitophorus salicivorus (Walker) Pass. Buckton, 2, p. 135.
Lachnus viminalis Boyer. Kaltenbach, 1874, p. 585. Del Guercio 1907 (1908) Redia V, p. 345.

S. cinerea L.
Aphis saliceti Kalt. Del Guercio, 1909 (1910) Redia VII, p. 297.
Chaetophorus salicivorus Passerini. Schouteden, 1906a, p. 213.
Chaetophorus salicti Schrank. Schouteden, 1906a, p. 213.
Lachnus viminalis (Boyer) (Aphis saligna Sulzer, Walker, p. 959). (A. salicina Zett.) (A. salicis Curtis) (Lachnus dentatus Le Baron) Del Guercio, 1907 (1908) Redia V, p. 345.
Melanoxantherium sp. Schouteden, 1906a, p. 215.

S. cordata Muhl.
Chaitophorus cordatae Williams. Williams, 1910 (1911), p. 27.
Chaitophorus viminalis Monell. Williams, 1910 (1911), p. 30.

S daphnoides Vill.
Lachnus viminalis (Boyer) Pass. (salicis Shaw?) (salicis Curtis?) (saligna Walker). Buckton, 3, p. 57.

S. discolor Muhl. Glaucous Willow.
Aphis (*Siphonophora*) *salicicola* (Thomas) Monell. Oestlund, 1887, p. 63.

S. fragilis L. (Russelliana). Crack Willow.
Aphis vitellinae Schrank. Kaltenbach, 1874, p. 585.
Lachnus viminalis Boyer. Kaltenbach, 1874, p. 585.

S. glaucophylla.
Chaitophorus n. sp. Sanborn. Sanborn, 1904, p. 34.

S. speciosa.
Aphis spectabilis Ferrari. Ferrari, 1872, p. 64.

S. triandra L.
Aphis vitellinae Schrank. Kaltenbach, 1874, p. 585.

S. viminalis L. Osier.
Aphis saliceti Kalt. Ferrari, 1872, p. 64. Del Guercio, Redia VIII, p. 297.
Aphis salicti Kalt. Theobald, 1911-12.
Cladobius populea (Kalt.) Koch. Passerini, 1863, p. 56.
Lachnus longirostris Fab.? (Aphis). Ferrari, 1872, p. 81.
Lachnus viminalis (Boyer) Pass. (A. saligna Walker?). Passerini, 1869, p. 64. (dentatus Le Baron) Del Guercio, 1907 (1908), Redia V, pp. 281, 345.
Melanoxanthus salicis (Linn.). Buckton, 2, p. 23.

S. vitellina L.
Aphis populea Kalt. Kaltenbach, 1874, p. 561.
Cladobius populea (Kalt.) Koch. Passerini, 1863, p. 56.

Lachnus longirostris Fab. Kaltenbach, 1874, p. 92.
Lachnus longirostris Pass. Kaltenbach, 1874, p. 562.

S. sp.

Aphis amenticola Kalt. Kaltenbach, 1874, p. 586.
Aphis cicutae Koch. (capreae Fab.) Kaltenbach, 1874, p. 585.
Aphis gracilis Walker. Walker, 1852, p. 1040.
Aphis saliceti Kalt. Kaltenbach, 1874, p. 585.
Aphis saliceti Schrank. Kaltenbach, 1874, p. 586.
Aphis salicicola (Thomas) Monell (A. brevifurca Monell MSS) Monell, 1879, p. 24.
Aphis salicicola Thomas. Gillette, 1910, p. 403.
Aphis salicina Zetterstedt. (Chaitophorus?) Tullgren, 1909, p. 6.
Aphis pilosa Haldeman (A. salicis?) Hunter, 1901, p. 102.
Aphis spectabilis Ferrari (? amenticola Kaltenbach). Schouteden, 1906a, p. 228.
Aphis truncata Hausmann. Lichtenstein, La Flore.
Chaitophorus populeus (Kalt.) (Lachnus punctatus Burm?) Buckton, 2, p. 139.
Chaitophorus salicicola Monell. (Lachnus salicicola Uhler?) Thomas, 1879, p. 105.
Chaitophorus salicis Williams. Williams, 1891, p. 27.
Chaitophorus viminalis Monell. Patch, 1913, Bul. 213, p. 80.
Chaitophorus sp. Davidson, 1909, p. 301.
Cladobius rufulus Davidson. Davidson, 1909, p. 300.
Lachnus dentatus Le Baron. Weed, 1890, p. 117.
Lachnus salicellis Fitch (L. salicicola Harris?). Thomas, 1879, p. 119.
Lachnus saligna Walker. Lichtenstein, La Flore.
Lachnus viminalis (Boyer) (L. dentatus Le Baron). Oestlund, 1887, p. 32.
Macrosiphum laevigatae Essig. Patch, 1913, Bul. 213, p. 84.
Melanoxantherium antennatum Patch. Patch, 1913, Bul. 213, p.
Melanoxanthus bicolor Oestlund. Weed, 1891, p. 290.
Melanoxantherium flocculossum (Weed). Gillette, 1909a, p. 385.
Melanoxantherium salicis (Linn.). Gillette, 1909a, p. 387, Patch, 1913, Bul. 213, p. 88.
Melanoxantherium salicti Harris. Patch, 1913, Bul. 213, p. 86.
Melanoxanthus salicis (Linn.). Weed, 1890, p. 115.
Melanoxanthus smithiae (Monell). Gillette, 1909a, p. 387; Patch, 1913, Bul. 213, p. 86.
Myzus achyrantes Monell. Sanborn, 1904, p. 71.
Myzus persicae Sulzer. Gillette and Taylor, 1908, p. 35.
Nectarophora californica Clarke. Clarke, 1903, p. 254.
Phylloxera salicicola Pergande. Pergande, 1904b, p. 269.
Phylloxerina salicis (Licht.) CB. Börner, 1909b, p. 60.
Pterocomma pilosa Buckton. Buckton, 2, p. 144.
Siphocoryne aegopodii Scopoli. Lichtenstein, La Flore.
Siphocoryne salicis Monell. Weed, 1893, p. 297.
Siphonophora salicicola Thomas. Thomas, 1879, p. 193.

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THE BIOLOGY OF POULTRY KEEPING

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BULLETIN No. 214.

THE BIOLOGY OF POULTRY KEEPING.*

RAYMOND PEARL.

There are certain phases or branches of agriculture which are from their very nature specialized and locally restricted either in space or time. The growing of beef cattle is not adapted to the conditions of the city back-lot not could it be considered sound economic policy for the Saskatchewan wheat grower to set out an orange grove. There is, however, one kind of farming, which in one form or another, knows no limitations of space, and only those limitations of climate which forbid any sort of agriculture whatever. This is poultry keeping. No plot of ground is too small to keep a few hens on, or at least to try to keep them on, and no ranch, however large, is complete without a flock of hens to furnish eggs for the table and perhaps a few over to sell. It may be safely said that there is no phase of agriculture which is so universal and wide spread over the whole world as poultry husbandry. The adaptability of the business is marvellous. Poultry raising may be, and probably has been, successfully combined with every other kind of farming known to man. One farm recently visited would seem to have about reached the limit in the way of oddity of the combination. This was a *fox and poultry farm.* Raising foxes was one part of the business, and raising chickens and turkeys the other part. Needless to say the two lines of endeavor were kept strictly apart.

When combined with other things as an integral part of diversified farming poultry keeping is usually one of the most profitable activities of the farm, and can be made so in every

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In order that progress may be made in the analysis of this important problem of inbreeding there is a fundamental need which must first be met. This is the need for an appropriate and valid method of pedigree analysis, which possesses generality, and can on that account be depended on to give comparable results when applied to two (or more) different pedigrees. Specifically, there seems not to have been worked out any *adequate general method of measuring quantitatively the degree of inbreeding which is exhibited in a particular pedigree.* Without such a measure it is clearly impossible to proceed far in the analysis of inbreeding.

It is the purpose of the paper of which this is an abstract to present a method for measuring, and expressing numerically in the form of a coefficient, the degree of inbreeding which exists in any particular case, and to show by illustrations the manner in which these coefficients may be computed. It is shown that the method is (a) *unique,* in the sense that the value obtained in any particular instance can only be affected by the degree or amount of inbreeding which has been practiced in the line of descent under consideration, and (b) *general,* in the sense that it is equally applicable to all pedigrees and to all degrees and types of inbreeding.

PRELIMINARY DEFINITIONS.

In attempting any general analysis of the problem of inbreeding from the theoretical standpoint one is confronted with the necessity for a definition of inbreeding, which shall be at once precise and general, that is, such as to include all of the most diverse ways in which this sort of breeding may be practised.

Leaving aside for the moment all consideration of details as to *how* a particular piece of inbreeding may be brought about is to be found the concept of a *narrowing* of the network of descent as a result of mating together individuals genetically *related* to one another in some degree. Let us take this as our basic concept of inbreeding. It means that the number of potentially *different* germ-to-germ lines, or "blood-lines" concentrated in a given individual animal is *fewer* if the individual is inbred than if it is not. In other words, *the inbred individual possesses fewer different ancestors in some particular generation or generations than the maximum possible number for that* *generation or generations.* This appears to be the most general form in which the concept of inbreeding may be expressed. In whatever way the mating of relatives is accomplished, or whatever the degree of relationship of the individuals mated together, the case in last analysis comes back to the above statement, namely that there are actually in the pedigree of the inbred individual fewer *different* ancestors in some particular generation or generations than the maximum possible number.

THE MEASUREMENT OF THE DEGREE OF INBREEDING.

This brings us to a consideration of a practical and general measure of the degree of inbreeding exhibited in a particular pedigree. This problem has been attacked by a number of other investigators, but so far as I have been able to learn, all previous measures have been modifications in one form or another of the scheme of Lehndorff. All systems based on the number of "free generations" alone, as in Lehndorff's, do not furnish a precise or reliable measure of the real intensity of inbreeding. The essential reason for this failure, stated baldly, is that they do not take account of the composition of the generation to which the "common ancestor" of an inbred pair belongs.

In developing a general measure of the intensity of inbreeding we may well start from the conception set forth in the preceding section, namely that the inbred individual possesses fewer different ancestors than the maximum possible number. Besides this factor account must be taken of the generation or generations in which the reduced number of different ancestors is found, and the extent to which these generations are removed (in the sense of Lehndorff mentioned above) from the individual or generation under consideration. In other words the two factors which must be included in a general measure of the intensity of inbreeding are (a) the *amount* of ancestral reduction in successively earlier generations, and (b) the *rate* of this reduction ever any specified number of generations.

Both of these demands are met by taking as a measure of the intensity of inbreeding in any generation the proportionate degree to which the actually existent number of different ancestral individuals fails to reach the maximum possible number, and by specifying the location in the series of the generation under discussion.

This statement is amplified and made more precise in the following propositions.

1. The production of the individual must be the point of departure in any analytical consideration of inbreeding, leading towards its measurement. That is, the question to which one wants an answer is: What degree of inbreeding was involved in the production of this particular animal?

2. It is therefore necessary practically to *start* with the individual and work *backwards* into the ancestry in measuring inbreeding, rather than to start back in the ancestry and work down towards the individual.

3. In the genetic passage from the $n+1$'th generation to the n'th, or in other words the contribution of the matings of the $n+1$'th generation to the total amount of inbreeding involved in the production of an individual, the degree of inbreeding involved will be measured by the expression

$$Z_n = \frac{100\,(p_{n+1} - q_{n+1})}{p_{n+1}} \qquad \text{(i)}$$

where p_{n+1} denotes the maximum possible number of different individuals involved in the matings of the $n+1$ generation, q_{n+1} the *actual* number of different individuals involved in these matings. Zn may be called a *coefficient of inbreeding*. If the value of Z for successive generations in the ancestral series be plotted to the generation number as a base, the points so obtained will form a curve which may be designated as the *curve of inbreeding*.

It will be noted that the coefficient of inbreeding Z is the percentage of the difference between the maximum possible number of ancestors in a given generation and the actual number realized in the former. The coefficient may have any value between 0 and 100. When there is no breeding of relatives whatever (that is, in the entire absence of inbreeding) its value for each generation is 0. As the intensity of the inbreeding increases the value of the coefficient rises.

4. The above measure of inbreeding has to do solely with the *relationship* aspect of the problem. It has nothing whatever

to do *directly* with the gametic or zygotic constitution of individuals.

5. Since the only possible infallible criterion of relationship between individuals is common ancestry in some *earlier* generation, we are led to the practical rule, in measuring the degree of inbreeding in a pedigree, *to regard all different individuals as entirely unrelated until the contrary is proved by the finding of a common ancestor.* This no doubt appears at this stage of the discussion as an exceedingly obvious truism. The reader is urged to accept it as such, and hold fast to it, because it will help him over some apparent paradoxes later.

The method of calculating coefficients of inbreeding, and their real significance will be made much clearer by the consideration of illustrative examples of their application. To these we may therefore turn.

THE CALCULATION OF COEFFICIENTS OF INBREEDING.

We may first consider some simple hypothetical pedigrees,

PEDIGREE TABLE I. (HYPOTHETICAL).

To illustrate the Breeding of Brother × Sister, out of Brother × Sister, Continued for a Series of Generations.

x	a	c	e	g
				h
			f	g
				h
		d	e	g
				h
			f	g
				h
	b	c	e	g
				h
			f	g
				h
		d	e	g
				h
			f	g
				h

before attacking the more complicated ones actually realized in stock-breeding.

Illustration I. Continued Brother × Sister Breeding.

Let us begin with the most extreme type of inbreeding possible, namely the mating of brother with sister for a series of generations. Pedigree Table I gives the pedigree of an individual so bred.

Let us now proceed to calculation of the coefficients of inbreeding Z_0, Z_1, Z_2, and Z_3. For Z_0 we have

$$p=2,$$

$$q=2,$$

whence $$Z_0=\frac{100\ (0)}{2}=0$$

In the same way $$Z_1=\frac{100\ (4-2)}{4}=50$$

$$Z_2=\frac{100\ (8-2)}{8}=75$$

$$Z_3=\frac{100\ (16-2)}{16}=87.5$$

These results may be expressed verbally in the following way: In the last two ancestral generations *x* is 50 per cent inbred; in the last three generations it is 75 percent inbred; and in the last four generations it is 87.5 per cent inbred.

This pedigree table and the constants will repay further consideration, since the case is a limiting one. With the table at hand it is possible to grasp a little more clearly the precise biological meaning of the coefficients of inbreeding. Thus it is seen that what the value of $Z_1=50$ really signifies is that because the individual *a* and *b* were brother and sister the number of different ancestors which *x* can possibly have in any ancestral generation cannot be *more* than 50 percent of the total number theoretically possible for the generation. That is, *x*'s sire and dam having been brother and sister means that *x* cannot have more than 2049 different great-great-great-great-great-great-great-great-great-grandparents, instead of the possible 4096. He may have had fewer than 2049, but $Z_1=50$ tells us that he could not have had more. Similarly $Z_2=75$ indicates that since *c* and *d*, the grand-sire and grand-dam of *x* were brother and sister, *x* cannot have in any ancestral generation more than 25 percent of the theoretically possible number of ancestors for that generation. And so on for the other values of *Z*.

In the limiting case of the closest inbreeding possible the successive Z's will have the values given in the following table.

TABLE I.

Values of the Successive Coefficients of Inbreeding (Z_0 to Z_{15}) in the Case of the Most Intense Inbreeding Possible (Brother × Sister Out of Brother × Sister Continued).

COEFFICIENT OF INBREEDING.	Ancestral Generations Included.	Numerical Value of Coefficient.
Z_0	1	0
Z_1	2	50
Z_2	3	75
Z_3	4	87.5
Z_4	5	93.8
Z_5	6	96.9
Z_6	7	98.4
Z_7	8	99.2
Z_8	9	99.6
Z_9	10	99.8
Z_{10}	11	99.9
Z_{11}	12	99.95
Z_{12}	13	99.98
Z_{13}	14	99.99
Z_{14}	15	99.994
Z_{15}	16	99.997

From this table it is apparent that while the narrowing or exclusion of the possible different source lines of descent proceeds very rapidly in the first few generations of brother × sister breeding, only relatively little change is made by further generations of this sort of breeding. Thus in seven generations of brother × sister breeding all but about 1 1-2 percent of the potentially different ancestral "blood-lines" will have been eliminated.

The values of the *Z*'s in Table I are maxima: No particular coefficient of inbreeding can have a higher value than that given in the table. It is not possible, for example, so to breed any domestic animal that its pedigree on analysis will give $Z_3 >$

87.5. If therefore, the coefficients of Table 1 are plotted the result will be the maximum limiting *curve* of inbreeding.

Illustration II. Parent × Offspring Breeding.

The next illustration of the application of coefficients of inbreeding will be the general case of back-crossing, that is the mating of parent × offspring.

The values of the successive coefficients for parent × offspring breeding for 16 ancestral generations are given in Table 2.

Table 2.

Values of the Successive Coefficients of Inbreeding in the Case of Continued Parent × Offspring Mating.

Coefficient of Inbreeding.	Ancestral Generations Included.	Numerical Value of Coefficient.
Z_0	1	0
Z_1	2	25
Z_2	3	50
Z_3	4	68.75
Z_4	5	81.25
Z_5	6	89.06
Z_6	7	93.75
Z_7	8	96.48
Z_8	9	98.05
Z_9	10	98.93
Z_{10}	11	99.41
Z_{11}	12	99.68
Z_{12}	13	99.83
Z_{13}	14	99.91
Z_{14}	15	99.95
Z_{15}	16	99.97

By comparison of this table with Table 1 it is evident that while the increase in intensity of inbreeding is not so rapid in the first few ancestral generations by this parent × offspring type of breeding as with the brother × sister type, by the time the 10th ancestral generation is reached the values are, for practical purposes, the same.

Illustration III. The Pedigree of the Jersey Cow, Bess Weaver (155121).*

Leaving now the hypothetical cases we may consider some pedigrees of actually existing animals. For a first illustration of this sort the Jersey cow Bess Weaver may be taken. Her pedigree through four ancestral generations is shown in pedigree table II.

PEDIGREE TABLE II.

Sex ♀ No. 155121 Bess Weaver	♂ No. 53598 Davy Stoke Pogis	No. 35913 ♂ Sisera's Stoke Pogis	No. 26271 ♂ Juno's Stoke Pogis	No. 14207 ♂ Alphea's Stoke Pogis
				No. 14436 ♀ Carlo's Juno
			No. 37346 ♀ Sisera	No. 18811 ♂ Duchess Stoke Pogis
				No. 6246 ♀ Edith Darby
		No. 79860 ♀ Baltimore	No. 19350 ♂ Patrick Fawkes	No. 10469 ♂ Regal Koffee
				No. 21574 ♀ Kermesse
			No. 17900 ♀ Avoca 2nd	No. 3286 ♂ Champion's Son
				No. 17769 ♀ Avoca
	♀ No. 126629 Peg Weaver	No. 35913 ♂ ⊕ Sisera's Stoke Pogis	No. 26271 ♂ × Juno's Stoke Pogis	No. 14207 ♂ × Alphea's Stoke Pogis
				No. 14436 ♀ × Carlo's Juno
			No. 87346 ♀ × Sisera	No. 18811 ♂ × Duchess Stoke Pogis
				No. 6246 ♀ × Edith Darby
		No. 126626 ♀ Kate Weaver	No. 36382 ♂ General Kelly	No. 19350 ♂ ⊗ Patrick Fawkes
				No. 95606 ♀ ⊕ Balm
			No. 95606 ♀ Balm	No. 7056 ♂ America's Champion
				No. 95605 ♀ Maid of Gilead 2nd

In the twelfth ancestral generation the theoretically possible number of different ancestors is 4096. In a relatively long pedigree, such as arises in dealing with registered cattle, it would obviously be an extremely tedious business to determine the value of q by direct counting, as has been done in the preceding simpler illustrations. The calculation of the coefficients of inbreeding may be greatly simplified in the case of long pedigrees by a system of counting which makes the *line of*

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* The illustrations from actual pedigrees used in this abstract are not the same as those used in the complete paper. The two illustrations here given are chosen because of their probably greater interest to the Station's constituency.

descent the unit rather than the individual. This system is used in the above pedigree as an illustration of method, although only 4 ancestral generations are here considered. While each individual animal which is eliminated because of previous appearances in a lower ancestral generation is marked with an *X,* those at the apex of a line of descent are marked with a cross within a circle. These latter are all that need to be counted directly. Their elimination automatically eliminates their own ancestors. Thus the bull Sisera's Stoke Pogis first appears in the second ancestral generation as the sire of Davy Stoke Pogis. He next appears (here marked with a cross within a circle) in the same generation as the sire of Peg Weaver. He will, by the general rule for coefficients of inbreeding, not be counted as a "different" ancestor the second time in this generation. But this automatically eliminates his two parents in the third ancestral generation, his four grandparents in the fourth generation, and so on until in the twelfth generation 1024 ancestors of Sisera's Stoke Pogis will be so eliminated. The same consideration applies in every other like case.

Practically then the method of dealing with a pedigree of this sort is first to go through and indicate in a distinctive way every *primary** reappearance of individuals. Then form a table on the plan of Table 3, the character of which is so obvious as not to need detailed explanation.

This table is to be read in the following way: Because of the reappearance of Sisera's Stoke Pogis in the 2nd ancestral generation Bess Weaver has 1 fewer ancestors in that generation than she would have had in the entire absence of inbreeding; 2 fewer in the 3rd generation and so on. The totals of the columns of this table are the values, for each generation, of

$$p_{n+1} - q_{n+1}$$

---

* By "primary" reappearance in the pedigree is meant a reappearance as the sire or dam of an individual which has not itself appeared before in the lower ancestral generations. Thus Patrick Fawkes makes a *primary* reappearance in the fourth ancestral generation as the sire of General Kelly, a bull which is not found in any generation below the third.

TABLE 3.

Working Table Used in Calculating the Coefficients of inbreeding for Pedigree Table II.

ANIMAL.	ANCESTRAL GENERATION.		
	2.	3.	4.
Sisera's Stoke Pogis	1	2	4
Patrick Fawkes	-	-	1
Balm	-	-	1
Totals	1	2	6

in (i). These totals, multiplied by 100, have then merely to be divided by p_{n+1} in order to obtain the successive Z's. The whole operation may be very quickly carried out. It is not necessary, in fact, to fill out the whole of the later columns of the table, the entries may be cumulated.

For the present pedigree we have

$$Z_0 = 0, \text{ as always*}$$

$$Z_1 = \frac{100\ (1)}{4} = 25\%$$

$$Z_2 = \frac{100\ (2)}{8} = 25\%$$

$$Z_3 = \frac{100\ (6)}{16} = 37.5\%$$

From these values it is seen that in the first four ancestral generations the cow Bess Weaver is 37.5 percent inbred. This is a perfectly definite figure, directly comparable with similar constants for other animals. Of course, if we were to go back more generations we should find Bess Weaver still more inbred, that is, the coefficients would grow larger with each case of the mating of relatives. Since the case is cited here merely for illustration of method, four generations only are considered.

---

* The apparent paradox implied in the fact that Z_0 must always be zero, or in other words that in the first ancestral generation, considered *alone*, there is no inbreeding will be cleared up, if it strikes the reader as paradoxical, by a reconsideration of the general principle numbered 5 on p. 127. The point of course is that it is impossible to say whether the parents are or are not related to one another until something is known of *their* parentage, or in other words, until a *second* ancestral generation is considered.

ILLUSTRATION IV. THE PEDIGREE OF THE JERSEY COW, FIGGIS 20th OF HOOD FARM (190306).

Figgis 20th of Hood Farm (190306) is a cow which, in official test for advanced registry, produced as a two year old 437 lbs. 14.4 oz. butter fat. This is a high record. The complete pedigree of this animal has been worked out for 12 ancestral generations, and the coefficients of inbreeding calculated. Twelve generations cover practically the whole of the known pedigree of this cow. On account of its great length it is impossible in the space here available to reproduce this pedigree. Nor is it necessary. The inbreeding coefficients in a quarter of a page give more clear and definite information regarding the amount of inbreeding practised in the breeding of Figgis 20th than could any visual inspection of the pedigree itself. Furthermore the list of names in Table 4 shows just what animals appear more than once in the pedigree, and how frequent are their reappearances.

Table 4 is precisely the same sort of table for Figgis 20th that Table 3 is for Bess Weaver.

In dealing with this and all other pedigrees it is assumed, in the absence of information on the point and the impossibility of acquiring any, that any imported animal for which there is no further pedigree, was not inbred to any degree whatsoever. This is probably not often strictly true, but, on the other hand, some assumption must be made, and this puts all individuals on an equal footing. It is in accord with the principle laid down earlier (p. 127) that in pedigree analysis all individuals must be considered to be unrelated until the contrary is proved by the evidence of their ancestry. After all, the only thing we can possibly measure is the inbreeding shown in the *recorded* pedigree. All that happened prior to the beginning of the record must be a matter of assumption. The *same* assumption should, however, be made for all cases. What this assumption really means practically is that, in all cases of analysis of actual pedigrees, which are bound after a time to come to an end, the values of the coefficients of inbreeding obtained are *lower limiting values*. They signify that the intensity of inbreeding in a particular case could not have been *less* than that indicated; it may have been more. Whether it was or not is not a question open to scientific determination but only to speculation.

From this table the following coefficients of inbreeding for Figgis 20th are easily calculated.

$Z_0 = 0$
$Z_1 = 0$
$Z_2 = 12.50$ percent
$Z_3 = 12.50$ "
$Z_4 = 21.88$ "
$Z_5 = 25.00$ "
$Z_6 = 32.03$ "
$Z_7 = 35.94$ "
$Z_8 = 37.30$ "
$Z_9 = 37.99$ "
$Z_{10} = 38.48$ "
$Z_{11} = 38.57$ "

These coefficients show that Figgis 20th was at least 38 1-2 percent inbred. That is, she had rather less than two-thirds as many different ancestors as she would have had in the event of no inbreeding whatever. It is further clear that most of this inbreeding took place in the fourth and earlier ancestral generations, chiefly in the fourth, fifth, and sixth generations.

Comparing Figgis 20th with Bess Weaver we see that the latter is practically as much inbred in the first 4 ancestral generations as Figgis 20th is in the first 12. Considering in each case only the first four ancestral generations the figures show that, within these generations, Bess Weaver is exactly 3 times more intensely inbred than Figgis 20th.

The Relation of Coefficients of Inbreeding to the Hereditary Constitution of the Individual.

What, if any is the relation of coefficients of inbreeding to the zygotic constitution (i. e., the hereditary make-up) of the individual? Do the coefficients tell us anything regarding this matter? A little consideration shows that they do. The successive coefficients of inbreeding indicate the rate and degree to which the possible number of *different* hereditary unit factors present in the ancestry is subsequently reduced as a result of inbreeding. They give no indication of the condition in which the *remaining* factors are present (i. e., whether in homogygous

TABLE 4.

Working Table for Calculating the Coefficients of Inbreeding of Figgis 20th.

ANIMAL.	ANCESTRAL GENERATIONS.									
	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Sophie's Tormentor	1	2	4	8	16	32	64	128	256	512
Ida's Stoke Pogis	–	–	1	2	4	8	16	32	64	128
Catono	–	–	1	2	4	8	16	32	64	128
Rosabelle Hudson	–	–	1	2	4	8	16	32	64	128
Khedive	–	–	–	1	2	4	8	16	32	64
Young Fancy	–	–	–	1	2	4	8	16	32	64
Stoke Pogis 3rd	–	–	–	–	1	2	4	8	16	32
Marjoram	–	–	–	–	1	2	4	8	16	32
Lord Lisgar	–	–	–	–	1	2	4	8	16	32
Tormentor	–	–	–	–	1	2	4	8	16	32
Oonan	–	–	–	–	1	2	4	8	16	32
Landseer	–	–	–	–	1	2	4	8	16	32
Optimus	–	–	–	–	1	2	4	8	16	32
Jersey Bull of Scituate	–	–	–	–	1	2	4	8	16	32
Hebe	–	–	–	–	1	2	4	8	16	32
Victor Hugo	–	–	–	–	–	1	2	4	8	16
Lord Lisgar	–	–	–	–	–	1	2	4	8	16
Victor Hugo	–	–	–	–	–	1	2	4	8	16
Roxbury	–	–	–	–	–	1	2	4	8	16
Gen'l Scott	–	–	–	–	–	1	2	4	8	16
Europa	–	–	–	–	–	1	2	4	8	16
Europa	–	–	–	–	–	1	2	4	8	16
Mollie	–	–	–	–	–	1	2	4	8	16
Sir Charles	–	–	–	–	–	1	2	4	8	16
Pharos	–	–	–	–	–	1	2	4	8	16
Clement	–	–	–	–	–	–	1	2	4	8
Hebe	–	–	–	–	–	–	1	2	4	8
Lady Mary	–	–	–	–	–	–	1	2	4	8
Fancy	–	–	–	–	–	–	1	2	4	8
Sir Charles	–	–	–	–	–	–	1	2	4	8
Mary Lowndes	–	–	–	–	–	–	1	2	4	8
Victor	–	–	–	–	–	–	1	2	4	8
Potomac	–	–	–	–	–	–	–	1	2	4
Splendid	–	–	–	–	–	–	–	1	2	4
Saturn	–	–	–	–	–	–	–	1	2	4
Saturn	–	–	–	–	–	–	–	1	2	4
Rhea	–	–	–	–	–	–	–	1	2	4
Countess	–	–	–	–	–	–	–	1	2	4
Dick Swiveller, Jr	–	–	–	–	–	–	–	1	2	4
Countess	–	–	–	–	–	–	–	–	1	2
Taintor	–	–	–	–	–	–	–	–	1	2
Comus	–	–	–	–	–	–	–	–	1	2
Comus	–	–	–	–	–	–	–	–	1	2
St. Clement	–	–	–	–	–	–	–	–	1	2
Major	–	–	–	–	–	–	–	–	1	2
Czar	–	–	–	–	–	–	–	–	1	2
Countess	–	–	–	–	–	–	–	–	1	2
Dick Swiveller	–	–	–	–	–	–	–	–	1	2
Dove	–	–	–	–	–	–	–	–	1	2
Diana	–	–	–	–	–	–	–	–	–	1
Custard	–	–	–	–	–	–	–	–	–	1
Prince John	–	–	–	–	–	–	–	–	–	1
Splendens	–	–	–	–	–	–	–	–	–	1
Totals	1	2	7	16	41	92	191	389	788	1,580

or heterozygous condition). The meaning here will be clear if a concrete example is considered. When one brother and sister mating is made 50 percent of the maximum possible number of different ancestors is eliminated. It is at least readily conceivable, if indeed it cannot be said to be highly probable, that no two individuals among higher animals and plants are *exactly* alike in zygotic constitution when *all* hereditary characters are taken into account. This means, in last analysis, that each individual must differ from every other by at least one unit factor, possibly more. Once mating of brother and sister will diminish the number of such differences by 50 percent from what it would have been had no such mating occurred. The number of homozygous individuals *with respect to the hereditary differences remaining,* however, will not increase. This is practically equivalent to saying that while self-fertilization increases the proportion of *individuals* homozygous with reference to all characters, the closest inbreeding other than self-fertilization, if continued, increases the proportion of *characters* with respect to which all individuals are homozygous. Thus while both processes tend towards uniformity in the progeny, it is a different kind of uniformity obtained in a different way, in the one case from what it is in the other.

While in the above discussion only brother × sister mating is mentioned it is clear that the same reasoning applies regarding the meaning of the coefficients of inbreeding in all other types of mating.

There are other theoretical relations of inbreeding coefficients which are of interest, but to discuss them in detail here is not possible.

CONCLUDING REMARKS.

In this paper has been presented in abstract a general method of measuring the intensity or degree of the inbreeding practised in any particular case. The method proposed is shown to be perfectly general. It is based on no assumption whatever as to the nature of the hereditary process. On the contrary it is founded on the most completely logical and comprehensive definition of the concept of inbreeding that it seems possible to formulate. This is, in simplest form, that the most fundamental objective criterion which distinguishes an inbred individual from one not inbred is that the former has fewer different ancestors than the latter. It is believed that the proposed coefficients of inbreeding may be made extremely useful in studies of the problem of the effect of inbreeding, whether in relation to its purely theoretical aspects, or in the practical fields of stock-breeding and eugenics.

Table Showing the Maximum Possible Number of Different Ancestors in the First Twenty Ancestral Generations (Obligate Bisexual Reproduction).

ANCESTRAL GENERATION.	Maximum Possible Number of Ancestors.	ANCESTRAL GENERATION.	Maximum Possible Number of Ancestors.
1	2	11	2,048
2	4	12	4,096
3	8	13	8,192
4	16	14	16,384
5	32	15	32,768
6	64	16	65,536
7	128	17	131,072
8	256	18	262,144
9	512	19	524,288
10	1,024	20	1,048,576

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COMPARATIVE STUDIES OF CERTAIN DISEASE PRODUCING SPECIES OF FUSARIUM.

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The genus, Fusarium, contains a very large number of species. The descriptions of many of these are very incomplete, frequently, being based on the examination of a single collection of material. Since cultural studies of certain species have shown that the same fungus may show quite different characteristics when the conditions for growth are changed, the validity of many of the species is called in question. For example, in certain species of Fusarium starting with material from a colony from a single spore it would be possible by growing the fungus on different culture media to bring about differences as great as those which have been used in the separation of species. In many cases, in those forms which are parasitic, the occurrence of a Fusarium on different though closely related hosts has been considered sufficient reason by certain writers for describing the fungus on each as a different species. A good illustration of this is found in the fungus causing the scab of a number of cereals. It was described under a different name on each host but the work of Selby and Manns * has shown that the same fungus causes the disease in several hosts. This was determined by growing the fungus from each host in culture, comparing the cultures and making cross inoculations.

It is probable that careful and extended cultural studies together with inoculation experiments will greatly reduce the number of species. One great difficulty lies in the incomplete descriptions which make it impossible in many cases to deter-

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* Selby, A. D., and Manns, T. F., Ohio Expt. Sta., Bul. 203, p. 231, 1909.

mine whether the fungus which is being studied has been described. In some cases, an investigator after making an extended study of a species of this genus has described it as new because of the impossibility of placing it among those already described and at the same time has pointed out the possibility that it may have been incompletely described under another name. These new species however in which the descriptions take into consideration the characters of the fungus under different conditions of growth make it possible to determine with a considerable degree of certainty whether a fungus which is being studied agrees with the description or not. In some cases the account of the study of a species may become so extended as to make it difficult for the reader to pick out the most important points. It would be very desirable if each person who works with a species of Fusarium would either keep the fungus in culture or would send a culture to a laboratory which would keep it growing so that others who desire to do so may obtain it for comparison. In the study of this genus, the comparison of species grown side by side under the same conditions is very desirable.

Interest in the genus has increased with the knowledge that a number of very important plant diseases are caused by species of Fusarium. There can be little question that with further study it will be found that some of them which have been regarded as saprophytes are parasites which cause a considerable amount of damage to living plants. Owing to the difficulty in determining the species and the amount of cross inoculation work which should be done in order to determine the extent of the parasitism of each, a large amount of study is necessary in order to come to definite knowledge in regard to the characteristics of each and its importance as a cause of disease.

On account of the lack of knowledge of the diseases caused by species of Fusarium in Maine, although such fungi were frequently encountered in the examination of diseased plant tissues, it has seemed desirable to make some study of the forms isolated from different hosts and to test their pathogenicity by means of inoculation experiments.

In the study of the fungi responsible for the decay of Maine apples, two species of Fusarium were isolated from decaying fruit in 1908. These fungi were grown in pure culture and were tested to determine the extent to which they would cause decay of ripe apples. It was found that each of these caused rot and at about the same rate as some of the well known apple decay fungi which were being studied at the same time. Not much work was done with these fungi until the next summer when green apples were inoculated and a decay was produced in each case. The decay of the green fruit was regarded as better proof that they are parasites than the rot of the ripe fruit because a number of fungi are able to grow on ripe apples which cannot attack green fruit. The organisms were re-isolated in pure culture in a sufficient number of cases to make sure that the decay was caused by the fungus with which the apple was inoculated. These strains were designated Fusarium I and Fusarium II from apple, or F I and F II. (See list on p. 222).

In looking up the subject, no reference was found to any report of a Fusarium decay of apples in America but it was found that Osterwalder * had studied and described such a decay in Europe. The fungus which causes the rot enters the apples through the blossom end and grows down into the cavity around the seeds spreading from here into the surrounding tissues. The tissues become light brown in color and bitter to the taste.

Osterwalder studied the fungus not only as it occurs in nature but in culture on a number of media and describes its characteristics in some detail. He regarded it as a new species, *F. putrefaciens.* Inoculations were made on both apples and pears and it was found that when the fungus was placed in wounds it caused decay, but attempts to produce infection through the uninjured epidermis resulted in failure. Only one such apple rotted and this rot was caused by another fungus, *Cephalothecium roseum* Cda.

The review of this article in Experiment Station Record, Vol. XVII, p. 50, says: "The author claims that the fungus is identical with that reported by Eustace as *Cephalothecium roseum* which causes a rot of apples. He agrees with Eustace † and others on the ability of this fungus to cause a rotting of the fruits in this way refuting the claims of a number of European investigators." The writer did not find anything in Osterwalder's account to indicate that he regarded *F. putrefaciens* and *C. roseum* as identical. In connection with the fact that *C. roseum* was isolated from an apple which decayed after inoculation with the Fusarium, the status of *C. roseum* as an apple decay is discussed but this is followed in the next paragraph by a discussion of the species of Fusarium which have been described from apple fruit with the result that it was decided that the Fusarium which had been studied should be regarded as a new species, *F. putrefaciens.*

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* Osterwalder, A. Ueber eine bisher unbekannte Art der Kernobstfäule verursacht durch *Fusarium putrefaciens* Nov. spec. Centrabl. Bakt. Zweite Abt. 13, 207-213; 330-338, 1904.

† Eustace, H. J., N. Y., State Sta. Bul. 227, 1902.

Owing to the similarity of the decay found in Maine to that described by Osterwalder and the fact that one of the fungi, F I, found here seemed to agree rather closely with the description of *F. putrefaciens,* a culture was secured from Dr. Osterwalder in July, 1909, and has been grown on the same media since that time for comparison with the species isolated in Maine:* Some slight differences have been observed in cultural characteristics chiefly in the red color of the mycelium. The red color is much brighter in the Maine form than in the European on the same medium under the same conditions. Inoculations of apples showed that *F. putrefaciens* and the similar form from Maine caused decay of fruit at so nearly the same rate that one could not be regarded as a more active cause of decay than the other.

Each year since 1908 a considerable number of apples have been found in which a Fusarium was causing decay. The Fusarium rot is easily distinguished from the other common apple rots in its later stages when the mycelium has grown out through the lenticels and has partially covered the surface of the apple. This aerial mycelium is white at first but soon takes on some red and yellow color. In the early stages it is not always possible to distinguish this rot from those caused by other fungi. The decayed tissues are light brown in color and are bitter to the taste. The skin of the apple is darker in color than in the case of apples rotted by Penicillium but not so dark as with Sphaeropsis or Glomerella.

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* See foot-note p. 254.

Fusarium may attack the apple fruit in 2 ways. Both of the species isolated in 1908 were first found growing in wounds on the surface of the fruits. Associated with them were other fungi, part of which proved to be parasites and part saprophytes when inoculations were made into apple fruits. Later each of the two species was found growing in the cavity around the seeds and spreading into the surrounding tissues to cause decay just as Osterwalder described for *F. putrefaciens.* In such cases the fungus enters the seed cavities through the canal which extends down from the blossom end and which does not become closed in some varieties. Apples which appear sound may show when cut open a growth of mycelium around the seeds. If such apples are kept in cold storage, the fungus cannot grow but when the apples are subjected to a higher temperature for several days the mycelium spreads into the surrounding tissues causing the loss of the fruit. Either F I or F II may be responsible for such decay. As will be shown later Fusarium forms from a number of sources are capable of causing rot of apple fruits upon inoculation but these two species are the only ones which have been found to occur on the fruit in nature to such an extent as to cause much loss. A third form was isolated from a decaying apple in 1909 but has not been found again.

While these species of Fusarium are to be regarded as causes of storage rot of ripe apples, that part of the infection which takes place through the blossom end probably occurs in most cases before the apples are placed in storage. In some cases, infection through wounds may also occur before harvesting as in apples injured by insects or by hail. Wounds caused by rough handling also serve as a place of entrance for these as for other rot fungi. In a few cases green apples on the tree showing growth of Fusarium on wounded places have been found. Fig. 105 shows the appearance of such an apple. The fungus was isolated from this apple and has been grown for more than two years in comparison with Fusarium I with the result that the two strains are regarded as belonging to the same species. This has been isolated a number of times from apples. In one lot of Milden apples which were under observation in 1912 mycelium of a Fusarium was found in the core in many cases. Later an attempt was made to isolate the fungus from each of 20 of the apples which were either partially or wholly decayed and in which the rot appeared to be caused by a species of Fusarium. Small pieces of decayed tissue were removed from the inner part of each apple and placed in plates containing 10 c. c. of prune agar. From 15 of the 20 apples pure cultures of Fusarium were found. The plates from the other apples showed a growth of Fusarium but there was also a growth of other fungi. Transfers were made from the plates to tubes and the growth on various media agreed very closely with that of F I. Tests were made of ten of these strains which proved that each was capable of producing decay in apples of three varieties, Baldwin, Mann and Bellflower. One strain was used in making inoculations of apples of each of the following varieties: Rhode Island Greening, Baldwin, Gano and Northern Spy, with the result that decay was produced in all.

F I grows readily on a large number of the culture media which are in common use in growing fungi for study. On sterilized bean pods, potato, carrot, turnip, and beet cylinders in tubes, a rather large amount of white aerial mycelium is produced within 3 to 5 days after transfers are made if the cultures are kept at a favorable temperature for growth. Usually within 5 days, red color begins to appear in the mycelium near the culture medium. In a few days, this covers the whole slant in vegetable cylinders and becomes a very bright red. When the cultures become older there is some yellowish and greenish yellow mycelium. This was especially noticeable on beet cylinder cultures three weeks old.

In cultures grown under favorable conditions, great quantities of spores are produced. In young cultures spores of many shapes and sizes are found. These include as one extreme one-celled spores, about 8 microns in length, which have usually been designated microconidia and as the other large, 5-septate spores, 52 microns in length, which have been called macroconidia. In older cultures of this fungus when the conditions of growth are favorable to their development, orange colored masses of spores are produced. The spores found in these sporodochia are more uniform in shape and size than those found in the young cultures, as shown in Figs. 86, 87 and 88.

Appel and Wollenweber * regard these as normal spores while the spores of various shapes and sizes are regarded as abnormal. They base much of their classification of species on the shape and size of the spores produced in sporodochia. According to their account the sporodochia are produced readily when fully developed normal spores are transferred to sterilized plant stems in tubes. If on the other hand, mycelium is transferred there is growth of much more mycelium and the sporodochia do not develop so readily, if at all. The writer is able to confirm this from the results of work with certain strains of this species from apple. Sporodochia appeared in the cultures and when transfers were made from these to potato cylinders the whole slant became covered with an orange colored mass of spores, after a few days' growth. On the same date transfers were made using material from the aerial mycelium from the same tube with the results that in the cultures from this source mycelium began to develop at once giving a growth so different in character from that which developed from spores that the two sets of cultures might be classified as belonging to different species or even genera if the classification was based on these cultures alone without regard to their origin.

F II from apple agrees in certain characteristics with F I. On the same culture media the two fungi give a somewhat similar appearance. Both produce an abundance of white aerial mycelium although the amount is slightly greater in F II. The red color is the same in the two forms and differs from that in the cultures of *F. putrefaciens,* F XII, sent to me by Osterwalder when all are grown on the same medium. In *F. putrefaciens* the red color is not so bright but seems dull in comparison and it extends to the aerial mycelium to a greater extent than in F I and F II so that there is not so much contrast between the white aerial mycelium and the red color next to the medium. This difference has been noted many times.

F II can be readily distinguished from F I by microscopic examination of the spores. In the former, an additional type of spore is found. These spores are obovate to pyriform in shape, the obovate spores usually being one-celled and pyriform spores

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* Appel, O., and Wollenweber, H. W. Grundlagen einer Monographie der Gattung Fusarium (Link). Arbeiten aus der Kaiserlichen Anstalt für Land-und Forstwirtschaft. Band VIII, Heft I, 1910.

2-celled. Very frequently in cultures 2 to 4 weeks old the spores of the obovate type in this fungus are about equal in number to those of the septate Fusarium type while in the same cultures when a few days old a much smaller proportion of obovate spores is found. This is especially striking when the spores are sown in prune agar plates. The young colonies begin to produce spores of the septate Fusarium type in 3 to 4 days but if the cultures are allowed to continue their growth for 3 to 4 weeks large number of spores of the obovate type are produced. Figs. 89 to 93 show the different forms of spores which are found in cultures of this fungus, F II and F IV being strains of the same fungus. The obovate spores are as a rule about 8 microns in diameter, the septate vary from 11 to 41 microns in length and from 2.75 to 5.5 in width. They are one to 5-septate and may be straight or curved. According to the system of Appel and Wollenweber the spores which occur in the young cultures on agar are to be regarded as abnormal.

The first thought to occur on finding spores of the obovate and pyriform types in cultures which in other respect are so strikingly similar to typical cultures of Fusarium is that the cultures must not be pure. Plating out and starting from colonies which had developed from single spores gave cultures which produced the different types of spores. Moreover, it is possible to find spores of the long type and of the obovate type cut off from the same conidiophore so that one is forced to the conclusion that the extremely different forms belong to the same fungus.

In the first examinations of fungi of the type of F II found in connection with studies of decaying apples, the writer felt no hesitancy in referring the fungus to that genus on account of its striking similarity to other species of the genus. Later when it was found that the obovate, pyriform, and septate spores belonged to the same fungus the question of its proper classification became more difficult. Of the many species of Fusarium, the writer found none which was described as producing spores of such a strikingly obovate form. However, it is to be remembered that only a comparatively small number of the species of Fusarium were described from material which had been under observation in culture for a long enough time that all of the spore forms could be taken into consideration. For example material of F II collected as it occurs naturally in decaying apples may show in some cases practically all spores of the septate Fusarium type while in other cases the obovate spores predominate. A description of the fungus which took into consideration either of these conditions without regard to the other would not be complete.

Soon after it had been determined that the different spore forms belonged to this fungus, the writer read Stewart and Hodgkiss'* account of the Sporotrichum Bud-Rot of Carnations and the Silver Top of June Grass. Stewart isolated a fungus from decaying carnation buds, studied it in culture and carried on inoculation experiments in which he proved that it caused the rot of the buds. Diseased buds were sent to Dr. Peck who described the fungus as a new species, *Sporotrichum anthophilum.* Some time before this, Stewart had found a similar fungus associated with the silver top of June grass which Dr. Peck had named *Sporotrichum poae.* The descriptions of both species were based on material as it occurs in nature.

When Stewart grew the fungi from the two sources in culture, it was found that they gave exactly the same kind of growth on a number of media. Both were characterized by the production of a large amount of white aerial mycelium and by red color next to the medium. The spores in both were obovate to pyriform with occasional septate spores of the type of Fusarium macroconidia. By means of inoculations, he showed that the fungus isolated from June grass would also cause the rot of carnation buds and therefore concluded that the two species, *S. poae* and *S. anthophilum* should be regarded as one species which should be called *S. poae* because that species name was used earlier than the other.

The writer was impressed by the striking similarity of the carnation bud-rot fungus and the fungus from apples which has been referred to as F II. The fungus from apples agrees with the description of the one from carnations and June grass in its rapid growth, production of a large amount of white aerial mycelium, production of red color on a number of media and in the spores which vary from the obovate type of Sporotrichum to the septate type of Fusarium. The chief difference which is to be noted is that the fungus studied by Stewart is described as producing a predominance of spores of the obovate to pyriform type while in the fungus isclated from apples in Maine the type of spore which predominates varies with the age of the culture and with the conditions of growth.

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* Stewart, F. C., and Hodgkiss, H. E. The Sporotrichum Bud-Rot of Carnations and the Silver Top of June Grass. N. Y. Agr. Exp. Sta. Technical Bulletin No. 7, 1908.

In response to a request for cultures of the carnation bud-rot fungus for comparison with the apple fungus, Stewart replied that after the completion of their studies the cultures had been allowed to die. Some of the old cultures had been saved, however, and these were sent. While the writer did not have the opportunity to see this fungus alive and growing under the same conditions as the fungus from apple, there seemed little reason to doubt that the two fungi were very closly related. The proportion of obovate spores seemed greater in the old cultures which were sent by Stewart than in old growths of the apple fungus. The fact that so few spores of the septate type were found caused Stewart to regard the fungus as being more properly classified in the genus Sporotrichum than in Fusarium, although he points out that no other species of Sporotrichum is described as having septate spores.

At about the same time that Stewart was studying the carnation bud-rot Heald* was investigating a similar disease in Nebraska. In Heald's first account of this disease published in Science† a species of Fusarium was regarded as the cause of the rot but in the later publication the causal fungus is considered to be *Sporotrichum anthophilum*. Later in this paper data will be presented which will show that the fungi encountered in the two cases were not necessarily the same. The writer determined by means of inoculation experiments that certain typical species of Fusarium can cause rot of carnation buds so that it is not impossible that Heald was working with two different fungi. On the other hand the bud-rot fungus may have shown a large proportion of septate spores in one case and of obovate spores in the other. The illustrations of the fungus in the later publication show no septate spores of the Fusarium type.

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*Heald, F. D. The Bud Rot of Carnations, Neb. Expt. Sta. Bul. 103, 1908.

† Science, N. S., 23:620, 1906.

The writer tried to secure a culture of the fungus but it was no longer available. Dr. Heald kindly offered, however, to examine cultures of the apple fungus and give his opinion as to its identity with the one which he had studied in connection with carnation bud-rot. After growing the apple fungus for some time he reached the conclusion that it was very similar to his carnation bud-rot fungus and should probably be regarded as belonging to the same species.

Soon after noticing the similarity of the carnation bud-rot fungus and the apple rot fungus which had been designated as F II, inoculation experiments were begun in which the one from apple was tested on carnations in order to determine whether it would cause bud-rot. A detailed account of the inoculations and the results is given later in this paper. Here it is sufficient to say that as the result of these inoculations it was found that not only F II would cause the rot of the buds but that what appear to be closely related fungi isolated from other hosts can also produce the same disease. It was also found that certain typical species of Fusarium were capable of causing the destruction of the buds.

Fungi of the same type as the carnation bud-rot organism seem to be quite widely distributed in nature. The question of whether these are to be regarded as strains of one species or as closely related species is a difficult one. A fungus which is very similar to the one associated with the carnation disease was isolated from an ear rot of corn in Illinois and described by Burrill and Barrett.* This fungus which they called Fusarium I from corn produced a large amount of white aerial mycelium which later shows red color next to the culture medium. It was described as producing spores of two kinds, obovate to pyriform microconidia and septate macroconidia of Fusarium.

In the fall of 1910 the writer asked Dr. Barrett if it would be possible to obtain a culture of this fungus for comparison with the apple decay fungus. At that time the cultures had been allowed to die in the Illinois Laboratory but Dr. Barrett offered to look over material of the apple fungus and give his opinion as to its identity with the corn Fusarium I. Later, in the fall of 1911, Dr. Barrett again secured cultures of the corn Fusarium and after growing it and the apple fungus for some time under the same conditions sent a culture (carried in this laboratory as F XXXVI) to the writer with the opinion that the two should be regarded as distinct.

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* Burrill, T. J., and Barrett, J. T. Ear Rots of Corn. Ill. Expt. Sta. Bul. 133, p. 86, 1909.

Examination of material from young cultures of the corn fungus shows that it produces a much greater proportion of obovate spores than does F II from apples. In this it agrees more closely with the carnation bud-rot fungus than do the forms isolated from apples.

In December, 1912, the writer made some study of the fungi associated with the decay of ears of flint corn in Maine. On some ears obovate spores were found and on others septate Fusarium spores. Cultures were made with the result that two strains or species were secured one of which, F XLVIII, produces large numbers of obovate spores with occasional septate spores while the other, F XLIX, produces many septate spores with a much smaller proportion of the obovate form. The first of these fungi agrees closely with the one secured from Illinois while the other seems to be identical with F II from apples, showing that this may also occur on ears of corn. Since in the culture studies the two strains have been found to require the same conditions for growth it is probable that both occur frequently on moldy corn. Not enough work has been done to determine which is the more common in Maine. To determine this would require a large number of isolations of the fungi from different sources and their comparison in culture. On account of the fact that no difference can be noted in their effects on corn the value of this work would be questionable.

In connection with this study, the writer has isolated fungi from a number of sources for comparison with F II from apple. In this way a considerable number of strains have been secured. Some of these have proved to be typical species of Fusarium, while a number although showing certain characteristics of Fusarium have been found to produce spores of the obovate type. In many cases these forms cannot be distinguished from typical species of Fusarium until a microscopic examination is made of the spores.

In May 1910 a diseased potato was sent to this laboratory by Dr. G. E. Stone of the Massachusetts Agricultural College. When material from the diseased surface of the tuber was examined septate Fusarium spores were found. Cultures were made from these and the fungus which developed, F IX, produced an abundance of spores of the obovate type such as had been found in F II from apples. Early in the study of this it was noted that while the growth of mycelium was very similar and the spores identical in shape and size to those of the fungus from apple the proportion of obovate spores was much greater in the potato fungus. With the latter, the septate spores were produced in the young colonies when obovate spores were sown in agar plates but when aerial mycelium began to develop the obovate spores were produced in greater numbers than the septate.

In September 1910 a fungus, F VI, was isolated from diseased ears of sweet corn. The same fungus has been found on sweet corn a number of times since, but it is probable that the total amount of loss caused by it is small. It agrees very closely in its characteristics with F IX described above from potato.

A fungus, F XIII, isolated from diseased heads of sunflower, *Helianthus annuus* L. shows the same characteristics as F II from apple. While in older cultures it produces large numbers of obovate spores there are always present a good proportion of spores of the septate Fusarium type. This fungus causes a complete decay of sunflower heads and destroys the seeds. Upon inoculation the sunflower fungus was found to cause a rot of carnation buds and 47 of the 71 buds inoculated were destroyed.

In June and July, 1911, a number of grasses on the University grounds and farm at Orono showed silver-top. These grasses were examined from time to time in order to determine whether the fungus which Stewart found associated with the silver-top of June grass in New York occurred in Maine and if it did occur to isolate it from as many different grasses as possible for comparison with similar fungi from other sources.

On June 7, 50 culms of June grass, *Poa pratensis,* affected with silver-top were examined and only one was found which showed the spores of a fungus. These spores agreed in size and appearance with those of *Sporotrichum poae*. Dilution plate cultures were made and in three days colonies had developed which were producing spores. These were of both the one-celled, obovate and the septate types. Transfers were made from the colonies in the plates to sterilized bean pods in tubes. When the growth on bean pods was examined three days later it was found that large numbers of the obovate spores had been produced and only a small proportion of the septate type. It will be seen that this fungus, F XXIV, agrees very closely in its characters with *Sporotrichum poae* as described by Stewart. It also agrees closely with Barrett's Fusarium I, F XXXVI, from corn from Illinois and with one of the fungi isolated from potato, F IX, and one from sweet corn by the writer, F VI. The fungus was tested on carnation buds by inoculating 24 buds of the Enchantress variety and 22 of these were destroyed.

After about 2 weeks, June grass was again examined. This time a large number of plants showed the presence of the fungus on the injured culms. The mites which Stewart and Hodgkiss found associated with the fungus were also found here.* The explanation of the common occurrence of the fungus at this time in contrast to its rare occurrence 2 weeks earlier is found in the fact that the second examination was preceded by a period of rainy and cloudy weather which was favorable to the growth of the fungus.

Fowl meadow grass, *Glyceria nervata* (Willd.) Trin. which had been injured by the grass thrips was examined June 28 and showed the presence of a fungus which seemed to be identical with the one from June grass, F XXIV. On July 7 a rather large number of plants were examined and the fungus was found to be of frequent occurrence. Dilution plate cultures were made, F XXVII, and later material was transferred from colonies to tubes of various media where the growth was so nearly the same as that of the June grass fungus that one could not be distinguished from the other.

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* Cary, see pp. 100 and 112 of the 18th Annual Report of the Maine Agricultural Experiment Station, attributes the "silver top" of Jnue grass and certain other grasses in Maine to the grass thrips ***Anaphothrips striata*** Osborn. Material examined during different seasons showed both the mites and the thrips associated with the diseased plants.

In the same way material was examined from plants of red top, *Agrostis alba* L., F XXV; timothy, *Phleum pratense* L., F XXVIII; and quack grass, *Agropyron repens* (L) Beauv., F XXVI, which had been injured by the grass thrips. In all of these, the fungus was found and isolations were made in each case. A fungus, F XXX, showing the same characteristics was also found associated with silver top of timothy collected in Indiana in July 1911. Another, F XXIX, a typical species of Fusarium was also isolated from some of the diseased culms from Indiana.

An ornamental grass, *Phalaris arundinacea* L. var. *picta* growing on the University campus also showed the presence of the fungus with obovate spores on the shrunken culms which had been injured.

The fungi isolated from these different grasses have the same cultural characters. When they are grown side by side on the same medium, it is impossible to distinguish one from the other. They also agree very closely with the one from potato, F IX, described earlier in this paper, with the fungus from sweet corn, F VI, and with Barrett's Fusarium I from corn, F XXXVI, from Illinois. Some work has been done to determine the relation of these fungi to the carnation bud-rot by means of inoculations of carnation buds. It will be remembered that Stewart produced bud-rot of carnations with the fungus isolated from June grass and from these results reached the conclusion that the fungus from June grass and the one from carnation buds should be regarded as one species, a conclusion which no doubt is correct. In the inoculation work carried on by the writer, there has been wide difference in the results obtained with the very similar fungi from different sources. With the fungi from June grass, F XXIV; red top, F XXV, and quack grass, F XXVI, the proportion of decayed buds was so great as to lead to the conclusion that if the decay of carnation buds is taken as a standard by which to measure their relationship, they would be regarded as one species. Some of the fungi which seem identical with the one from June grass, F XXIV, in cultural and morphological characters did not cause a rot of carnation buds. These include the fungus from fowl meadow grass, F XXVII, Barrett's corn Fusarium I, F XXXVI, and the fungus with obovate spores from potato, F IX. On the other hand a number of cultures of typical Fusarium which could not possibly be considered as belonging to the same species as the fungi with obovate spores have been found to cause rot of carnation buds upon inoculation. It would seem that a number of species can cause carnation bud-rot but that what appears to be one morphological species isolated from different host plants has certain strains which cause the rot and others which do not. The fungus from fowl meadow grass seems identical with that from June grass yet it failed to attack carnation buds of the same variety that were destroyed by the June grass fungus. F II from apple and the sunflower fungus, F XIII, caused rot of the buds which was exactly the same in appearance as that caused by the June grass organism although they differ from it in the production of a much larger proportion of septate spores and might possibly be regarded as belonging more properly to a different species. *Fusarium putrefaciens,* F XII, and F I from apple caused rapid decay of carnation buds and there is no question but that these are typical Fusarium forms.

In the course of this study species of Fusarium have been isolated or secured from a number of different sources and have been carried through periods of growth on the same media as the forms with obovate spores for comparison. Cultures of two species of Sporotrichum, *S. roseolum* Oudem. and Beyer and *S. bombycinum* (Corda) Rabenh. were secured from the Association Internationale des Botanistes and these have been carried in culture for more than two years. These species bear little resemblance to the fungi with obovate spores which are under consideration as they produce almost no aerial growth on any of the media on which they have been grown. The writer has had little experience with the genus Sporotrichum, never having grown but one other species in culture but after growing several fungi of the same general group, if not strains of the same species, as the carnation bud-rot fungus in comparison with a number of typical species of Fusarium, some of which resemble that fungus in certain characteristics, and taking into consideration that Sporotrichum is a genus characterized by producing one-celled spores while Fusarium is a genus in which different types of spores are produced in a given species under different conditions of growth, it would seem that this group of fungi should be considered as more closely related to Fusarium than to Sporotrichum.

Cultures of the fungus which has been called F II from apple showing both obovate, one-celled spores and septate spores were sent to Dr. Peck in March, 1910, together with a letter calling attention to the similarity of the apple fungus to that causing carnation bud-rot and to the fact that in the cultures of the fungus from apple large numbers of spores of the septate type were present. In replying Dr. Peck stated that in describing the fungi from June grass and carnation buds only material as it occurs in nature was examined. For that reason only spores of the obovate type were observed. Dr. Peck also said that he knew of no genus which would properly include a fungus with spores of both the Sporotrichum and Fusarium types. It may be possible that the fungi with these two kinds of spores constitute a group of species which should be placed in a new genus. It is well known, however, that many species of Fusarium produce in culture large quantities of spores of such shape and size as to place them in other genera if the classifications were based on these spores which are usually called microconidia. The writer believes that the obovate spores in the group under consideration should be regarded in the same way that the small spores of a Cephalosporium type are regarded in certain species of Fusarium and that the fungi with obovate spores agreeing in other characteristics with Fusarium can safely be included in that genus.

As has been stated, a number of typical species of Fusarium have been carried in culture side by side with the fungi already discussed and used to some extent for comparison with them. *F. roseum* Lk, F XVIII, was isolated from scabby wheat which was kindly sent to the writer from Ohio by Dr. Thomas Manns, then of the Ohio Agricultural Experiment Station.* This fungus produces a large amount of white aerial mycelium with bright red color next to the culture medium. In appearance the cultures closely resemble those of F II from apple but microscopic examination shows that the wheat scab fungus produces very few spores in culture and none of these are of the obovate form.

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* See foot-note p. 254.

In September 1910, a Fusarium was found on glumes of wheat in Maine. The fungus, F VIII, was isolated and has been found to agree in cultural characters with F I from apple. There is less aerial mycelium than in *F. roseum,* F XVIII, secured from Ohio and spores are produced in large quantities in sporodochia. These masses of spores are orange colored. When apples were inoculated with this fungus it caused as much decay as F I from apple.

A fungus, F XXXI, isolated from summer squash in the summer of 1911 agrees somewhat closely in cultural characters with F II from apple. There are, however, a very small proportion of spores of the obovate type. The spores agree in appearance with those of other fungi which have been described in this paper. This fungus produces such a large proportion of septate spores that it would seem that its classification should be based on these rather than on the obovate spores. It is difficult, however, to separate the fungi which produce spores of these types and place all which show a large proportion of septate spores in the genus Fusarium and those which produce a smaller proportion in another genus.

A species of Fusarium, F XL, was found causing rot of squashes in storage in December, 1911. This fungus produced much white aerial mycelium with red and yellow color near the medium. The decaying tissues of the squash took on a bright red color.

A fungus, F XVII, similar to the one from squash was isolated from ears of yellow dent corn from Indiana. The growth of this fungus agrees very closely wih that of the one from squash when they are grown on the same culture medium. The corn fungus grew rapidly and produced the same effects on squash as the squash fungus when both were used in making inoculations. Neither of these strains has produced many spores in cultures.

A fungus which agrees in cultural characters with *F. oxysporum* as described by Smith and Swingle * was secured from two sources, Ohio, F XVI, and Vermont, F XV, and these strains have been grown on a number of media.†

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* Smith, Erwin F., and Swingle, Deane B., Bureau of Plant Industry. Bulletin 55, 1903.

† See foot-note p. 254.

A fungus F VII isolated from diseased cucumbers in Maine has agreed closely with these fungi in its growth. This was striking in the experiments testing the effect of different amounts of several acids on growth. In each case these 3 strains were able to grow in media containing larger amounts of acid than any of the other 21 strains used in these tests. Two other species of Fusarium have been obtained from diseased cucumbers. One of these, F XX, shows some blue color in the mycelium while in the other, F XIX the mycelium remains white. All of these strains from cucumber produce large numbers of chlamydospores in the cultures. These chlamydospores may occur singly or several may occur together in the hypha. Two strains from tomato, F XXI and F XXII, and one from squash, F XXIII, agreed closely with the strain from cucumber in which the mycelium remained white.

In addition to the forms from potato which have been mentioned four others have been isolated. One of these, F XXXVIII, which was isolated from sporodochia on stems has shown the same cultural characters as F I from apple, and the fungus, F VIII, isolated from wheat in Maine. When apples were inoculated with the potato fungus, rot followed. The other three fungi illustrate very well the fact that a number of species of Fusarium may occur in stored potatoes and that some of these species can be easily distinguished form one another by their growth on a few culture media. One of these forms, F XXXIII, showed blue color of mycelium, one red, F XXXV, and the other white, F XXXIV, when grown on potato cylinders. These fungi have been under observation for two years and have not shown variation from these colors except in the case of the red which has not been uniform.

Each summer for the past three years specimens of China aster, the stems of which were affected with a fungous disease, have been sent to this laboratory. In each case cultures have been secured by taking material from the inner part of the stem, using sterilized instruments. The cultures secured from different sources give evidence that the same fungus, F XIV, is responsible for the disease in different localities. The fungus shows a small amount of white aerial mycelium and no color has appeared in the cultures. The spores are mostly of the non-septate type but occasional septate spores are seen. Chlamydospores occur in the cultures. No inoculations have been made on China asters.

LIST OF ORGANISMS STUDIED.

F I.	Fusarium I from apple fruit.
F II.	Fusarium II form apple fruit, produces obovate spores.
F III.	Fusarium III from apple fruit.
F IV.	Fusarium IV from apple fruit, produces obovate spores.
F V.	Fusarium from ears of sweet corn from Orono. This did not produce obovate spores.
F VI.	Fusarium from ears of sweet corn from Monmouth, Me. This produces many obovate spores.
F VII.	Fusarium isolated from decaying cucumber. Closely resembles F XV and F XVI from potato.
F VIII.	Fusarium isolated from diseased wheat collected in Maine.
F IX.	Fungus with obovate spores from potato. Isolated by Dr. W. J. Morse from a potato tuber sent from Massachusetts by Dr. Geo. E. Stone.
F X.	Fusarium from Red Astrachan apple. This fungus is identical with F II.
F XI.	Fusarium isolated from a green apple which was decaying on the tree August 1, 1910. This fungus is apparently identical with F I.
F XII.	*F. putrefaciens* Osterwalder.* Culture secured from Dr. Osterwalder in 1910 and carried in culture since that time in comparison with the Maine forms.
F XIII.	Fusarium from sunflower. Isolated from decaying head of sunflower from garden in Orono.
F XIV.	Fusarium from China aster. Isolated from stems of diseased plants sent by Mrs. E. C. Bodman of Seal Harbor, Maine. September, 1910.
F XV.	Agrees closely in cultural characters with *F. oxysporum** as described by Smith and Swingle. This strain was secured from Vermont through the courtesy of N. J. Giddings.
F XVI.	A culture of this fungus which was isolated from internal tissues of potato tuber from Sharpsburg, Ohio, was secured from Dr. Thomas Manns. Fungus seems identical with F XV.

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* See foot-note p. 254.

F XVII.	Fusarium from yellow dent corn. Isolated from decaying ear of corn sent from Indiana. January, 1911.
F XVIII.	*F. roseum* Lk.* Isolated from diseased wheat which was secured from Dr. Thomas Manns then of the Ohio Experiment Station.
F XIX.	Fusarium isolated from decaying cucumber. This fungus differs from F VII in that the mycelium remains white in old cultures while in F VII it takes on some purple color on certain media.
F XX.	Fusarium isolated from cucumber by Dr. W. J. Morse. Grows slowly and produces less aerial mycelium than XIX. Shows some blue color in old cultures. Spores are mostly 3-septate.
F XXI.	Fusarium from tomato. Isolated from decaying tomato. Similar in cultural characters to F XIX.
F XXII.	Fusarium from tomato. This strain seems to be identical with F XXI.
F XXIII.	Fusarium from squash. Isolated from decaying squash. Very similar in cultural characters to F XXI.
F XXIV.	Fungus isolated from June grass which showed silver top June, 1911. This fungus is identical in cultural characters with the one which Stewart isolated from June grass and which he regarded as identical with the carnation bud-rot fungus.
F XXV.	Fungus isolated from red top which showed silver top, 1911. Identical with F XXIV.
F XXVI.	Fungus isolated from quack grass, 1911.
F XXVII.	Fungus isolated from fowl meadow grass, 1911.
F XXVIII.	Fungus isolated from timothy from Maine, July, 1911.
F XXIX.	Fusarium from timothy from Indiana, 1911. This is a typical species of Fusarium and does not show the obovate spores.
F XXX.	Fungus with obovate spores from timothy which showed silver top. From same lot of material as F XXIX. F XXX is identical in cultural characters with the forms isolated from the different grasses in Maine.
F XXXI.	Fusarium isolated from summer squash, July, 1911. This fungus produces a small proportion of obovate spores in cultures.
F XXXII.	Fusarium isolated from diseased stem of garden pea, July, 1911.
F XXXIII.	Fusarium in which the mycelium takes on a blue color. Isolated from potatoes in storage, 1911.

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* See foot-note p. 254.

F XXXIV.	Fusarium with white mycelium from potato. From same lot of potatoes as F XXXIII.
F XXXV.	Fusarium in which the mycelium takes on red color. Isolated from the same lot of potatoes as F XXXIII.
F XXXVI.	Fungus secured from Dr. Barrett from Illinois. This culture was a later isolation which Dr. Barrett regarded as identical with the fungus described as Fusarium I from corn in Illinois Bulletin 133.
F XXXVII.	Fusarium from Milden Apple. Culture from a strain isolated by M. Shapovalov, November, 1912. This fungus is identical in cultural characters with F I.
F XXXVIII.	Fusarium from potato stems. Culture started from sporodochia on stems, September, 1912. There was no evidence that the fungus was growing as a parasite. This strain shows cultural characters identical with F I and it also caused rot of apple fruit upon inoculation.
F XXXIX.	*F. vasinfectum* var *pisi* Van Hall. Culture secured from Centralstelle für Pilzkulturen, September, 1912.
F XL.	Fusarium from decaying winter squash. This fungus which was isolated December, 1911 shows strikingly different cultural characters from F XXIII as F XL produces much white aerial mycelium with red and yellow color near the medium.
F XLIV.	Fusarium from China aster. Isolated from diseased stem of China aster sent from Winter Harbor, Maine, in 1908.
F XLV.	Fusarium from China aster. Isolated from material from Seal Harbor, Maine, August, 1911.
F XLVI.	*F. niveum* Smith. Culture secured from Kral in February, 1910.
F XLVII.	Fusarium strains a, b, c, d, and e. All seem to be the same species as F I unless it is e. Isolated from decaying Milden apples December, 1912.
F XLVIII.	Fungus with obovate spores from flint corn. Same cultural characters as F XXXVI. Isolated from decaying corn from Winslow, Maine, January, 1913.
F XLIX.	Fusarium with small proportion of obovate spores. Isolated from same lot of corn as XLVIII.

CULTURE STUDIES.

On account of the fact that certain species of Fusarium show very different cultural characteristics when grown under different conditions, it is difficult to compare the forms from different sources unless they can be grown on the same medium under the same conditions. The desirability of growing the fungi which are to be compared on a number of culture media should be readily apparent.

In this work comparative studies were begun with the forms isolated from apples and later other fungi were included so that with most of the media forms from 24 sources, F I to F XXIV, were grown on each medium at the same time. This number was used in comparing the effect of different sugars and acids on growth and also in the studies in which fermentation tubes were used.

In all of the work reported here, each form was grown on at least two tubes or plates of the medium and in many cases this was repeated several times. Cylinders of vegetables, as potato, turnip, carrot and beet are very satisfactory media for the growth of species of Fusarium. When potato cylinders are prepared in the same way from time to time and the cultures are kept under the same conditions in other respects there is very little variation in the appearance of the mycelium of a given strain. The writer has observed no striking changes in the cultural characters of certain species of Fusarium which have been grown upon this medium with frequent transfers for four years. The species of Fusarium are usually regarded as very variable, but what have been considered as variations can probably be explained in every case as responses to changed conditions.

Some of the most important characters to be made use of in comparing representatives of this genus are: mycelium as to amount of aerial growth and color, presence or absence of chlamydospores, shape and size of conidia, and with those forms which are parasitic, the extent of the parasitism should be determined by means of inoculations.

Owing to the incompleteness of many of the published descriptions, these characters have little value in placing forms in the described species. The amount of aerial growth and the color of the mycelium may be very different in sets of cultures of the same fungus on different media. A species which on one medium may show much bright red color of the mycelium next to the substratum and extending to the aerial growth may show little or no red color in cultures of the same age on another medium. In this same fungus, other conditions may lead to the production of still other colors. On the other hand there are certain species in which the mycelium remains white whatever culture medium is used. In regard to color, it is not sufficient to state that a form shows a given color without giving some account of the conditions under which this color was produced. In cultures of a given species, the spores may show differences in shape and size. For this reason the measurements of spores as they are usually given in descriptions of species may apply equally as well to the spores of another. Any description of a new species of Fusarium should be based on cultural studies extended enough so that the characteristics which are brought out by growth under different conditions can be taken into consideration.

There are some media, however, which do not have much value in furnishing characters of growth which can be used in the separation of species of this genus. In these studies considerable work was done in comparing the growth of species from different sources on media which contained different amounts of sugars and acids. In general, the conditions which are favorable to the growth of one species seem to be favorable to others. For example, the amount of a given acid which when added to a 2 per cent dextrose broth renders the medium so acid that one of the forms which has been tested will not grow prevents the growth of all. The only exception to this was with the strains F VII, F XV, F XVI, which grew in media which contained enough acid to prevent the growth of other species. The following account gives the cultural characters of a number of forms on different media.

GERMINATION OF SPORES.

The species isolated from apple were studied in hanging drop preparations of the spores and this taken together with observations of the germination of the spores of other species in agar plates gives the basis for the statement that Fusarium spores germinate very readily when they are placed under favorable conditions for growth. Frequently, in cultures where there is a large amount of moisture present, spores germinate soon after they are produced.

Spores of F I from apple, taken from a culture three weeks old on turnip cylinder, were placed in a number of hanging drops of a decoction of apple wood at 4 P. M. The next day at 8 A. M. nearly all of the spores had germinated and in some cases the germ tube had branched. Other cultures were made in the same way at 9 A. M. and when these were examined at 4.30 P. M. all stages of germination were found. In some spores, the germ tubes grow out from the end cells in the direction of the long axis. In other cases, the germ tubes grow from the sides of other cells, the end cells being empty of contents. Fusions frequently take place between the germinating spores as shown in Fig. 94.

Spores of F II from apple taken from a bean pod culture three weeks old were sown in hanging drops of apple wood decoction at 10.30 A. M. At 2.30 P. M. the greater part of these spores had germinated. The next day at 2 P. M. considerable mycelium had developed and many spores were being formed. Most of these were of the long septate type but some obovate spores were seen.

Spores of F III from apple were sown in hanging drops at 9.15 A. M. At 4 P. M. many of these spores had germinated. As a rule the germ tubes grew out from the end cells in the direction of the long axis of the spores but in some cases the germ tubes developed from the sides of other cells.

Spores of F IV from apple, a fungus identical with F II, were taken from an agar plate culture and sown in hanging drops of 2 per cent saccharose broth where they began to germinate in 4 to 5 hours. The large septate spores germinate in the same ways that have been described for spores of the other species from apple. The small non-septate spores germinate after a little longer time than the large septate ones. They may or may not become septate before germination. The mycelium developed rapidly so that at the end of 24 hours a branched growth had formed from a single spore. After two days conidia were being produced. These were mostly of the obovate and pyriform types, although the long type were not rare. Cross walls were not seen in the long spores until after they had separated from the conidiophores.

Spores of F IV from apple, the greater part of which were of the obovate type, were placed in hanging drops of distilled water, potato broth, and dextrose broth at 3.30 P. M. At 8 A. M. the following day many stages of germination could be observed. The obovate spores become somewhat swollen and put out as a rule a single germ tube which soon branches. The spores sown in distilled water germinated well but the growth was soon checked while the mycelium in the broths made good growth and spores were formed.

GROWTH ON VEGETABLE CYLINDERS.

Cylinders of vegetables in tubes make excellent media for the growth of the mycelium of species of Fusarium. At the present time the writer has strains from 50 sources representing, however, a smaller number of species, all of which grow well on cylinders of potato, beet, turnip and carrot. These media and especially the potato are used for keeping the stock cultures and, in addition to this, series of cultures of the different strains have been made in which a number of the fungi are grown on the different vegetables at the same time for comparison.

Potato Cylinders. All of the strains of Fusarium which have been isolated here have been grown on this medium. The amount of aerial mycelium and the color which develops are of value in placing the forms from different sources in large groups. Part of these have produced a large amount of white aerial mycelium with bright red color next to the potato, others have shown a white mycelium with no other color except some browning in old cultures, while others have developed blue color.

The following fungi have shown a bright red color on this medium. F I, F II and F IV from apples together with a number of other isolations from apples which proved to be identical with one or the other of these, all the forms with obovate spores which were isolated from various hosts, *F roseum,** F XVIII, from wheat sent from Ohio, another Fusarium, F VIII, isolated from wheat grown in Maine, 2 strains, F V and F VI, from ears of sweet corn collected in Maine and another from yellow dent corn from Indiana, F XVII, one from decaying winter squash, F XL, and one from summer squash, F XXXI. This color usually appears in 3 to 7 days after the transfers are made when the cultures are kept at room temperature and exposed to the light from a North window.

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* See foot-note p. 254.

Species of Fusarium from the following sources have been carried in culture on this medium for almost three years and have always shown white mycelium: One species from cucumber, F XIX; two strains from tomato, F XXI and F XXII, probably one species; one from squash, F XXIII; three different isolations from diseased stems of China aster, F XIV, F XLIV, F XLV, and one from decaying potato, F XXXIV A species from stored potato, F XXXIII, and one from cucumber, F XX, have produced blue color.

Beet Cylinders. This medium was favorable to the growth of all the species of Fusarium which were tested upon it. In general the growth on beet is very similar to that on potato with possibly a little more red color in those species which produce it.

F I from apple nearly covered the slants after 4 days growth. One tube showed bright red color at the surface of the liquid and extending up along the glass where the cylinder was in contact with the wall of the tube. There was also some red color over the surface of the slant. The other tube did not show quite so much but there was some mixture of red and yellow. One week later there was little difference in the appearance of the 2 tubes. When the cultures were one month old septate spores were found which measured 4 x 25 to 41 microns.

In the tubes of F II from apple the white aerial mycelium almost fiilled the space between the slant and the wall of the tube and extended 8 mm. above the top of each slant at the end of four days. Red color showed at this time on the surface of the medium and was especially bright where the cylinder was in contact with the wall of the tube. The amount of aerial mycelium was greater with this fungus than with F I. One week later the red color was becoming dull and some yellow had appeared. There was a small amount of browning in the aerial growth. When the cultures were one month old examination showed the presence of spores of different types. The most abundant were obovate in shape and about 8 microns in diameter but there were many septate spores 4 to 5.5 x 14 to 20 microns and consisting of 2 or 3 cells. There were also non-septate spores of the shape that usually occurs in cultures of Fusarium. No long septate spores were observed at this time.

F III from apple does not make as great a growth on any medium which has been used as the other forms from apples. On the beet cylinder cultures four days old, the mycelium covered a little more than one-half of each slant. There was very little aerial growth and this was white in color. No red color ever appeared in these cultures, although occasionally a little red color has been observed on other media.

The growth of F IV from apple was identical in appearance with what has been described for F II. Spores of the same type were found in the cultures.

Another fungus, F X, which was isolated from Red Astrachan apples which were decaying around the core had exactly the same cultural characters on this medium as F II.

The fungus, F XIII, from sunflower heads produced the same amount of aerial growth, the same colors and the same types of spores as the strains with obovate spores from apples.

Strains of a fungus from potato, F IX, and sweet corn, F VI, which produced both obovate and septate spores with a predominance of the obovate type were grown on this medium and gave cultures which in color and amount of mycelium agreed quite closely with the forms described above from apples and sunflower. Comparisons showed, however, that the cultures from apple and sunflower produced a larger proportion of septate spores than the similar fungi from other sources.

The mycelium of *F. putrefaciens,** F XII grown over the entire surface of the slants when the cultures were 4 days old. Not so much aerial mycelium had developed as in the forms with obovate spores but about the same amount as in F I from apple. The color differed from that in the Maine form, however, the red and yellow of the European fungus being dull in comparison. The dull red color extended to the aerial mycelium to a much greater extent than in any other fungus in this set of cultures. In cultures one month old large numbers of spores were found. These varied from non-septate spores 8 microns in length to spores 47 microns in length with 5 septa. The spores of this fungus are very similar to those of Fusarium I from apple.

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* See foot-note p. 254.

A strain of Fusarium, F XI, which was isolated from an apple which was decaying on the tree August 1, 1910, and another, F VIII, isolated from wheat collected at Orono in September, 1910, were so similar to Fusarium I from apple when the three fungi were grown on beet cylinders that they could not be distinguished when placed side by side.

F. roseum, F XVIII, from wheat produced a luxuriant growth of white aerial mycelium and bright red color developed next to the medium. There was slightly more aerial mycelium than in the cultures of the fungi with obovate spores. Careful examination of material from these tubes showed only a few spores.

A fungus, F XVII, isolated from decaying ears of yellow dent corn sent from Indiana produced a growth very similar to that of *F. reseum* but there was some yellow color as well as red in the fungus from corn.

The species of Fusarium from cucumber, squash, and tomato grew well on beet cylinders but the amount of aerial mycelium was small in comparison with that of the forms which have been described and the color was white.

The 3 strains from cucumber seem to be distinct species although they agree closely in certain characters. One strain, F VII, has agreed closely with *F. oxysporum,* F XV and F XVI, from potato. On certain media this fungus has produced some purple color. Chlamydospores were formed in the cultures on beet cylinders and the conidia were of the one-celled type for the most part. One of the other strains from cucumber, F XIX, has agreed with this in spore characters but the color has remained white except for some brown in old cultures. The third form, F XX, produces less aerial mycelium than the others, the conidia are mostly three-septate and chlamydospores occur in the cultures. The first two forms would seem to be closely related to each other and to *F. oxysporum* as described by Smith and Swingle while the third should be placed in another group of species.

One Fusarium with white mycelium from squash, F XXIII, and the two strains from tomatoes, F XXI and F XXII, have resembled very closely in their growth the species from cucumber in which the mycelium remained white. These fungi in addition to chlamydospores produced larger rounded cells with a small amount of contents. These cells were as much as 30 microns in diameter in some cases.

Carrot Cylinders. The growth on this medium was so nearly identical with that on beet cylinders that the details will not be given. The most striking characteristic was the early development and brightness of the red color in those strains which have been described as showing this color on potato and beet. There was much red color on this medium at the end of 3 days.

Turnip Cylinders. All of the fungi made a good growth on this medium. There was not so much development of the red color on turnip as on potato, beet and carrot. Microscopic examination showed that the spore production agreed with that on beet.

Synthetic Agar. The species of Fusarium studied produce a good growth of mycelium on this medium which is prepared according to the following formula:

Dextrose	50	g.
Peptone	10	"
Ammonium nitrate	10	"
Potassium nitrate	5	"
Magnesium sulphate	2.5	"
Potassium monophosphate	2.5	"
Calcium chloride	0.1	"
Agar	20	"
Distilled water	1000	c. c.

This agar was titrated and made neutral with NaOH but it was found that upon sterilizing changes took place which rendered the medium somewhat acid. However, the medium which has been treated in this way with NaOH is more satisfactory for the growth of fungi than the same medium without this treatment.

The fungi were grown both in Petri dishes which contained 10 c. c. of the medium and on slants in tubes which contained 5 c. c. The appearance of the growth of a number of the fungi in Petri dishes is shown in Fig. 95 to 104. The development of red color was held somewhat in check on this medium in that it did not appear so early nor spread so rapidly as in the growth on some other media.

F I from apple spread rather rapidly, so that at the end of one week the mycelium had reached almost to the edges of the plates. The amount of aerial growth was less than in F II from apple. Viewed from the under side there was some yellow color and some red, but 3 days later the red color had increased so that one of the plates showed red over more than one-half of the under surface. Large quantities of spores were produced and when these were examined on the tenth day they were found to range from small one-celled to 5-septate spores 55 microns in length.

F II from apple made a very rapid growth on synthetic agar. At the end of one week the Petri dishes, which were almost 10 cm. in diameter, were filled with white aerial mycelium. Viewed from the under side both cultures were slightly yellowish and one showed some reddish color at the center. When the cultures were 10 days old both obovate and septate spores were found in large numbers. More than one-half of these were septate.

All of the strains with obovate spores from various sources have been grown on this medium. They have all agreed in the production of a large amount of white aerial mycelium and in showing some red or yellow color on the under side. The forms from apple and the one from sunflower have differed from the others in the production of a larger proportion of septate spores, but in other characters could not be distinguished from the other strains.

In the young cultures, *F. putrefaciens,* F XII, showed about the same amount of white aerial mycelium as F I from apple. When the cultures were one week old the mycelium took on a yellow color.

The Fusarium which was isolated from an apple which was decaying on the tree, F XI, the one from wheat collected at Orono, F VIII, and F I from apple made a very similar appearance on this medium, adding to the evidence that these strains belong to one species. All produced about the same amount of white aerial mycelium and all showed some yellow and considerable red color when the plate cultures two weeks old were viewed from the under side.

F. roseum. F XVIII, from wheat made a rapid growth and the Peri dishes were completely filled by the white aerial mycelium when the cultures were 5 days old. Later a small area which showed red color appeared at the center of each plate. A small number of septate spores were found in these cultures.

The forms from cucumber, F VII and F XIX, squash, F XXIII, and tomato, F XXI and F XXII, produced a rather large amount of white aerial mycelium. The one species from cucumber, F XX, which has been referred to as making less growth than the others on other media did not spread so rapidly in the plates as the others and could easily be distinguished from them. The culture of this fungus is shown in Fig. 104. All of the forms from cucumber produced chlamydospores.

The Fusarium, F XIV, F XLIV and F XLV, from China aster made a good growth but only a small amount of aerial mycelium developed. The color was white throughout. The spores were nearly all of the small one-celled type.

Prune Agar. The prune agar used in this work was prepared by making a decoction from 6 large prunes for each 1000 c. c. and adding 2 per cent dextrose and 2 per cent agar. It has been found that when too many prunes are used the agar becomes soft and that the use of a small enough number of prunes to give a solid agar makes the medium too poor in food for good growth of fungi. It was thought that adding 2 per cent dextrose to the agar containing the decoction from 6 prunes in 1000 c. c. would overcome both of these difficulties and the results have been fairly satisfactory. Species of Fusarium grow readily on this agar but do not produce aerial mycelium to such an extent as on synthetic agar. Prune agar is a favorable medium for the production of red color in those species which are characterized by the development of that color.

Fusarium forms I, II, and IV from apples spread rapidly over the plates but showed only a small amount of white aerial growth. Red color appeared at the center of the plates in 3 to 5 days and a little later the whole of each plate showed deep red, when viewed from the under side, except for a little yellow in F I. In the plates of F II and F IV the small amount of white aerial growth produced large numbers of spores of the obovate type.. When these spores were sown in other plates of prune agar the young colonies first produced long, septate spores and later, on the aerial growth, large numbers of obovate spores developed.

F III from apple developed no aerial mycelium on this medium. When the cultures were 3 weeks old many spores were being formed. These were aggregated in a number of little masses surrounding the center of each plate. The large hyphæ showed some yellow color.

All of the fungi from various sources which have been described as producing obovate spores agreed quite closely with what has been described for the similar strains from apples. Some of these did not produce as large a proportion of septate spores as the strains from apple but all did produce septate spores in young colonies when the obovate spores were sown in plates of prune agar. This has been observed so frequently in forms from different sources as to give evidence that the development of the different types of spore depends to a large extent on the conditions of growth.

F. putrefaciens, F XII, differed very much in its appearance on this medium from the other apple fungi. No red color developed but instead many of the large hyphæ showed a deep yellow color.

The Fusarium from wheat, F VIII, which has been referred to as giving a growth identical with that of Fusarium I and other strains from apple gave further evidence of this relation when grown on this medium as the growth was very similar.

F. roseum, F XVIII, made a rather rapid growth so that 3 days after the transfers were made the colonies were 2.5 cm. in diameter. At that time the central part of each colony was deep red, the color extending out a little more than one-half of the distance from the center to the edge of the growth. At the end of one week, the mycelium covered the entire surface of each plate and showed a deep red color identical with that in the forms with obovate spores. Careful examination failed to show the presence of spores.

The forms from cucumber, tomato and squash produced only a small amount of white aerial mycelium. One of the species from cucumber, F VII, agreed with cultures of *F. oxysporum*, F XV and F XVI, from potato in showing at the center of each plate an area of reddish purple color. All of the species from cucumber produced chlamydospores on this medium.

F. oxysporum, F XV and F XVI, from potato made good growth on prune agar but did not produce much aerial mycelium. When the cultures were one week old, the center of each plate had taken on a reddish purple color for an area of about 4.5 cm. in diameter. At three weeks old, the dark reddish purple color had spread over the entire surfaces of the plates and a small amount of white aerial mycelium had developed. Examination showed large numbers of one-celled spores. Material from near the center of one plate showed chlamydospores.

Prune Decoction. This medium was prepared by cooking 6 large prunes in a part of the water, filtering the decoction and making up the filtrate to 1000 c. c. The fungi were grown in tubes containing 5 c. c. of this material. All of the forms which were tested made some growth but this was not a favorable medium for normal development. The mycelium spread through the liquid and in many cases formed a pellicle on which a small amount of aerial mycelium developed. Material from cultures of different ages was examined and it was found that few spores were produced and that these were abnormal as compared with spores of the same fungus grown on more favorable media.

Sugar Broths. In order to determine whether the growth in media containing different sugars would bring out characteristics which might be used to assist in classification, beef extract broths were prepared each of which contained one per cent of a different sugar and each of the strains, F I to F XXIV, was grown in the different media at the same time for comparison. The sugars used were dextrose, saccharose, lactose, and mannite. It was found that all the strains made good growth of mycelium in each broth but that dextrose and saccharose gave better growth than the others. None of the cultures gave a normal development of spores. The conclusion is that the use of sugar broths has no value in the classification of these fungi.

GROWTH IN FERMENTATION TUBES.

All of the 24 strains which were used in the other culture work were grown in fermentation tubes. Each fungus was grown in two tubes for each medium and the following media were used: one per cent dextrose, saccharose, lactose and mannite broths, and 5 per cent glycerin broth. None of the fungi grew in the closed end of the fermentation tube in any of these broths and none produced gas so the fermentation tube proved to be of no diagnostic value.

RELATION OF GROWTH TO ALKALI AND ACIDS.

One per cent dextrose broth was used as the basis for the media in testing the effects of different strengths of alkali and acids upon the growth of strains from 24 sources. It was found that all of these fungi made good growth even when large amounts of NaOH were added to neutral dextrose broth. At — 60 of Fuller's scale only a little difference could be noted when the tubes were compared with cultures of the same age growing in the neutral broth. When larger amounts of NaOH were added, the growth was less so that at — 100 a distinct difference could be noted in the amount of growth as compared with the check cultures. There was a small amount of growth in all of the tubes at — 150 NaOH but no growth took place when the medium was made — 200 of Fuller's scale. Not enough difference in the growth of the different forms in relation to the alkalinity of the medium could be observed to be of value in the separation of species.

In determining the amount of acid which prevents the growth of Fusarium, the acids used were hydrochloric, sulphuric, nitric, lactic, oxalic, and formic. Normal solutions of these acids were prepared and these were added to neutral one per cent dextrose broth in sufficient quantity to make the medium of the desired acidity. The same fungi which were used in the other culture work were grown in the media which were the same except for the amount and kind of acid which had been added. Two tubes were used for each fungus with each strength of a given acid. The amount of an acid which prevented the growth of one of the fungi had the same effect on the others except for the strains, F VII, F XV and F XVI, which grew in media which contained sufficient acid to prevent the growth of the others.

Hydrochloric, nitric, and sulphuric acids were unfavorable to the growth of all the forms when added in sufficient quantity to make the broth + 20 of Fuller's scale. At + 40 the growth was very much checked and at + 50 there was no growth. With lactic acid, there was a small amount of growth up to + 100 of Fuller's scale but above + 60 the strains of *F. oxysporum* showed better growth than the others. Oxalic acid checked the growth at + 40 and there was very little growth of any strains except those of the *F. oxysporum* type at + 60. At + 80 no other forms showed growth. With formic acid all of the tubes showed a small amount of growth at + 20, at + 30 there was very little growth and no growth in any at + 40.

GROWTH IN RELATION TO TEMPERATURE.

There was very little growth of any of the 24 forms, F I to F XXIV, when transferred to potato cylinders and kept at a temperature of 5° C., or below. At 15° C. there was good growth but not so much as at 20° to 25° C. When cultures were placed in the incubator at a temperature of 30° C. the growth was not so rapid as at 20° to 25° C. At 33° C. it was less than at 30°, and those forms which produce a bright red color at lower temperatures showed a rather dull red and in a part of the forms yellow instead of red. At 37° C. none of the strains showed growth at the end of one week but when after that time the cultures were removed from the incubator and kept at room temperature most of the fungi made good growth.

GROWTH FROM OLD CULTURES.

Growth from old cultures has been reported for a number of species of Fusarium. By making transfers from time to time it was found that cultures of the species isolated from apples in Maine and also of *F. putrefaciens,* F XII, on bean pods, apple wood, and potato cylinders were alive after a period of 18 months in which the cultures became dried out at the temperature of the laboratory.

TESTS OF PATHOGENICITY.

Apple Inoculations.

Apples have been inoculated with each of the species of Fusarium isolated from apples and also with strains from other sources and it has been found that those isolated from apples and some of the strains from other host plants cause decays of the fruit which are equal in amount and very similar to the rot caused by *F. putrefaciens,* F XII, which has been used for comparison. While these fungi are not so active as causes of decay as the apple rot fungi Sphaeropsis and Penicillium, yet they are capable of causing complete destruction of apples when the conditions are favorable for their entrance and growth.

October 28, 1908, five apples were inoculated with material of F I from a pure culture. The fungus caused a distinct decay and was re-isolated in pure culture from the rotted tissues.

December 5, 1908, five apples were inoculated with material from a pure culture of F II from apple. The fungus soon showed evidence of growth and at the end of five days each apple showed a small decayed area at the point of inoculation. After two weeks the rot had spread to include an area which was from 1.5 to 2.5 cm. in diameter. Pieces of the decaying tissue were removed with a scalpel which was sterilized by flaming and each piece was placed in a Petri dish which contained 10 c. c. of prune agar. The fungus grew out from the tissues in each case and examination proved that the growth was identical with that of the fungus which was used in making the inoculations. The decayed tissue was quite bitter to the taste.

Ten green apples were inoculated August 10, 1909, with material from a pure culture of F I. At the end of 4 days an area about 6 mm. in diameter surrounding each point of inoculation was decayed and some white mycelium had developed. The rot spread slowly but at the end of one month the apples varied from one-half to two-thirds decayed. The diseased tissue was light brown in color, soft; and bitter to the taste when held on the tongue half a minute or more. Plates were made and the fungus was re-isolated in pure culture from the decaying tissues.

Sets of 4 Bellflower apples were inoculated January 4, 1910, with each of the following fungi: F I, II, III and IV from apple, F XV from potato, and F XIV from diseased stem of China aster. After 6 days all of the apples which had been inoculated with the Fusarium forms from apples and with F XV showed decay. The decayed area was about one cm. in diameter in each case and no difference could be noted in the rot caused by these fungi. The fungus from China aster did not cause rot of apples. The appearance of some of the inoculated apples is shown in Figure 111. As much difference could be noted among the apples inoculated with a given fungus as among those inoculated with the 5 fungi from different sources. The taste of the decayed tissue was slightly bitter in all of the apples except those in which the decay was caused by F XV in which no bitter taste could be detected.

August 19, 1910, 6 green apples were inoculated with each of the following fungi; F I, II, and III from apples, F XII, received from Europe, as *F. putrefaciens,* and what was called *F. oxysporum* from each of 2 sources, F XV and XVI. On September 1 all the apples showed some decay but in some cases the amount differed considerably in the 6 apples inoculated with the same fungus. F II caused less decay than the other fungi in this set of inoculations. Figures 108 to 110 show the appearance of the rot on a part of the apples.

Fusarium forms from 16 sources, including strains, F I, F II, F III, F XI, and F XII, from apple, F IX, from potato F VII, and F XX, from cucumber, F XXII from tomato, F V and F VI from sweet corn, F VIII and F XVIII from wheat, F XIII from sunflower, and F XIV from China aster, were used December 9, 1910, in making inoculations of Greening apples. All made some growth at the points of inoculation but this variety seemed to be resistant to the attack of these fungi and only a small part of the apples showed much decay. There was considerable difference in some cases in the amount of decay in different apples inoculated with the same fungus as has been noted in other sets of inoculations. In this set of inoculations, some of the fungi from other host plants caused as much decay as fungi which had been isolated from apples. It was found that the Fusarium isolated from wheat, F VIII, and which agreed closely with F I from apples caused a distinct decay of these apples. A Fusarium isolated from cucumber, F VII, and which agrees closely with the strains carried as *F. oxysporum* from potato caused as much decay of apples as any fungus which was used in this set of inoculations.

Green McIntosh apples were inoculated August 10, 1911, with strains of Fusarium, F I to F XXVI. The fungi made some growth of mycelium at the points of inoculation but did not spread into the green fruit to cause much decay.

September 1, 1912, Duchess apples were inoculated with strains of Fusarium from 34 sources. Observations from time to time for one month showed that all of these fungi made a little growth but that none of them caused much rot.

January 9, 1913, one Mann apple and 2 Baldwins were inoculated with material of each of 7 strains of a fungus, F XLVII, of the type of F I from apple. Each strain was isolated from a different decaying Milden apple.

One week after inoculation there was a decayed region about 1.5 cm. in diameter at each of the two points of inoculation on each Mann apple. Little difference could be noted in the decay caused by the different strains. The decay spread more slowly in the Baldwin than in the Mann apples. One month after inoculation the Mann apples were almost entirely rotted while the Baldwins showed decayed areas 2 to 3 cm. in diameter.

January 17, 1913, Bellflower apples were inoculated with 40 strains of Fusarium isolated from different sources. One week later all of the fungi showed some growth at the points of inoculation. The strains of F XLVII from Milden apples caused decay more rapidly than any of the others. Later observations showed that strains of this fungus whether isolated from apples, wheat, or potato caused more decay of apples than any other forms used. The forms with obovate spores from various sources did not cause nearly so much decay in this set of inoculations as the fungi of the type of F I from apple. There was in some cases considerable difference in the amount of decay in different apples inoculated with material from the same culture. The results of the inoculation work would seem to justify the conclusion that a number of species of Fusarium may cause decay of apple fruit but that strains of one species are more actively parasitic than the others.

INOCULATIONS OF PEARS.

Three pears were inoculated September 16, 1909, with material of F II from apple. The fungus spread rather rapidly through the tissues and caused the complete decay of the pears. The mycelium of the fungus grew out over the surface forming little tufts.

August 16, 1910, 3 green pears in each case were inoculated with F I, II and III from apple and with F XII, the organism carried as *F. putrefaciens*. Eight days later each of the pears showed a decayed area about one cm. in diameter. F XII and F I grew out around the points of inoculation producing mycelium of a dull red color. F II and III showed white aerial mycelium at the points of inoculation and Fusarium II was producing large numbers of spores, most of which were of the obovate type although some septate spores were observed. One month after the time of inoculation the entire surface of each pear inoculated with F XII or with F I was covered by mycelium which showed red, yellow and white colors. These two fungi gave a very similar appearance on the decaying pears. Fig. 112 to 114 are illustrations showing the extent of the decay 17 days after the time of inoculation.

POTATO INOCULATIONS.

Potato tubers have been inoculated a number of times with each of the Fusarium forms isolated from apples as well as with forms from other sources. The potatoes were inoculated by making a small injury with a sterilized needle or scalpel and placing in this a small amount of fungus material from a pure culture. The inoculated tubers were kept in closed glass jars at the temperature of the laboratory. Nearly all of the fungi made some growth at the points of inoculation but this did not spread into the uninjured tissues to cause decay. Surface injuries to the potato tuber soon become dried out and covered by a corky layer which prevents the entrance of the mycelium unless the tubers are kept under conditions of considerable moisture.

CUCUMBER INOCULATIONS.

Species of Fusarium have been isolated from decaying cucumbers a number of times at this laboratory. In order to determine the extent to which these species and others would cause decay, cucumbers were inoculated with material of the forms isolated from cucumber, F VII, F XIX, F XX, squash, F XXIII, China aster, F XIV, sweet corn, F VI, apple F XII, and F II. All of these fungi caused a rapid decay. The appearance of 2 of the inoculated cucumbers is shown in Figs. 117 and 118.

INOCULATION OF CARNATION BUDS.

Owing to the similarity in cultural characteristics of the fungus with obovate spores from apple and the carnation bud rot fungus described by Stewart and Heald, it was decided to test the apple fungi on carnation buds in order to determine whether or not they would cause the bud rot. Later, the work was extended to include fungi from a number of other sources, a part of which were typical species of Fusarium. Four varieties of carnation were used,—Enchantress, Windsor, Gómez and Lady Bountiful. All of these, except the Gomez, were susceptible to the attack of part of the fungi which were used in making the inoculations. This variety proved to be very resistant and only a very small per cent of the Gomez buds were injured by any fungus which was tested. The Enchantress was used to a greater extent than either of the other varieties in comparing the amount of injury caused by different fungi.

All of the inoculations were made in the same way. A small injury was made in the side of the bud with a sterilized needle and a small amount of material from a pure culture was pushed in through the opening. Usually this material consisted of both mycelium and spores. In a few of the earlier experiments, the plants bearing inoculated buds were placed under bell-jars so that the buds were in a moist atmosphere favorable to the growth of the fungus. This procedure was followed for only a very short time as it was felt to be desirable to test the fungi under greenhouse conditions rather than under the abnormal conditions of a moist chamber.

The detailed account of a number of inoculation experiments follows. In the first part of the work only a small number of plants were available so the number of buds used in the earlier experiments was necessarily small.

Two buds of the Enchantress variety were inoculated March 4, 1910, with material of the apple fungus, F IV. The plants were placed under bell-jars and were kept covered for three days. At the end of this time it could be noted that the fungus was making some growth at the points of inoculation. The buds did not increase much in size and 12 days after inoculation the calyx of each bud appeared somewhat discolored. One bud was examined and it was found that all parts inside the calyx were destroyed by the fungus. When material from the decayed petals was teased out on a slide and examined with a microscope, spores of both the obovate and septate types were found, although the number of either kind was not great. The outer covering of the other bud was removed with instruments sterilized by flaming and the inner decaying part was placed in a tube containing 5 c. c. of sterile distilled water. White aerial mycelium grew out from this and the second day large numbers of spores were being produced, a part of which were obovate and a part of the long septate type. After 5 days the mycelium formed a thick red pellicle over the surface of the water. The white aerial mycelium was bearing many spores of the obovate and pyriform types which agreed in size with the spores of the carnation bud rot fungus.

April 21, 1910, 3 Enchantress buds were inoculated with F IV from apples. One of these buds was removed and examined 4 days later when the fungus showed only a small amount of growth. Two days later one of the other buds was examined and it showed that the fungus was making considerable growth in the tissues. April 29, 8 days after inoculation, the third bud was examined. All parts inside the calyx were destroyed and spores of the fungus were found. It is probable that if the first 2 buds had not been examined until 8 or 10 days after inoculation they would have shown a greater amount of decay as the fungus was growing in each at the time of examination and it has been found that about 10 days are necessary under favorable conditions for the complete destruction of the buds.

On account of the similarity in cultural characteristics of the fungi with obovate spores and certain species of Fusarium it was decided to test a number of fungi which gave evidence of being typical species of Fusarium to see if these also would cause decay of carnation buds.

April 20, 1910, 3 buds of Enchantress were inoculated with F I from apple and check punctures to which no fungus material was added were made in 2 buds. Five days later one of the buds, which was large at the time of inoculation, had opened and showed no decay. April 27 both of the others showed all inside the calyx destroyed and large numbers of spores of the fungus used in making the inoculations were present. One of the check buds was entirely open April 30 and showed no decay, the other opened a few days later and showed no injury from the puncture.

Since F I had caused decay another typical culture of Fusarium later found to be identical with F I was tested. April 28, 4 small buds were inoculated with F III from apple. One week later one of these was examined and it showed a small amount of decay of the petals and stamens. May 9 two other buds were examined and they showed more decay than was noted in the one examined May 5. When the last bud was examined, May 11, the interior was badly decayed.

May 5, 1910, 4 buds were inoculated with F III. May 16, 3 of the buds were badly rotted while the fourth remained healthy.

Five Enchantress buds were inoculated with F IV May 5 and were all badly rotted one week later. Three buds inoculated with the same fungus May 18 were decayed at the end of one week.

May 12, 1910, 2 Enchantress buds were inoculated with each of the fungi, F I, II and IV, from apple. All of these 6 buds were destroyed by the fungi within 10 days.

F XII, the organism carried as *F. putrefaciens,* is in every respect a typical species of the genus. July 11, 1910, 26 Enchantress buds were inoculated with this fungus. Eight days later, 21 of the buds were badly rotted. Material from a part of these was examined and septate spores of the Fusarium were found with no evidence of the presence of any other fungus.

July 26, 1910, 12 buds were inoculated with F XII and punctures were made in 13 buds to serve as checks. The injuries to the check buds were exactly like those in the others except that no fungus material was placed in the wounds. Examination 11 days later showed that all of the 12 inoculated buds were ruined by the fungus while the 13 checks were opening and showed no bad effects from the punctures.

F II from apple was used in making inoculation of 42 Enchantress buds July 11, 1910. Eight days later, 34 of these were badly decayed, 4 showed a small amount of injury and 4 were not damaged at all by the fungus. Eight buds were inoculated with F II July 26, 1910, and 11 days later all were rotted while one bud which had been punctured as a check had opened to a perfect flower except for the place broken by the puncture.

F XV from potato was used in making inoculations of 30 Enchantress buds August 18, 1910. None of these buds decayed. September 14, 13 buds were inoculated with the same fungus and 6 of these showed a small amount of rot, although the fungus did not spread through the tissues so rapidly as the different strains from apples.

August 26, 1910, 25 buds were inoculated with F IV and all of these rotted.

September 15, 1910, 18 buds were inoculated with F I and 30 buds with F III from apple. Of the 18 buds inoculated with F I, 11 decayed and of the 30 inoculated with F III, 20 decayed

The fungus, F XIII, with both obovate and septate spores from sunflower was used October 17, 1910, in making inoculations of 18 buds of Enchantress. Two weeks later 10 of the 18 buds had been destroyed by the fungus.

The Gomez variety was found to be very resistant to the fungi which caused a rot of Enchantress and other varieties which were used in later experiments.

Fourteen Gomez buds were inoculated August 26, 1910, with F I from apple. When these were examined 18 days later only one had rotted.

September 30, 1910, 37 Gomez buds were inoculated with the fungus, F XIII, from sunflower. Only 4 of these buds showed rot after 17 days.

F II from apple was used in making inoculations of 95 Gomez buds November 3, 1910. Observations from time to time indicated that the fungus was not causing decay and that the buds were developing normally. When a careful examination was made November 21 it was found that nearly all the buds had opened into perfect flowers. A few were slightly injured but none badly rotted.

In 1911 tests were made of part of the fungi which had been used in 1910 on 2 other varieties of carnation, Lady Bountiful and Windsor, and a number of fungi which had not been used in 1910 were tested on these varieties as well as on Enchantress.

May 4, 1911, 37 Enchantress buds were inoculated with F II from apple and punctures were made in 22 buds as checks. May 22, 20 of the inoculated buds showed decay and one of the 22 checks had become infected and was also rotted.

May 24, 1911, 30 Enchantress buds were inoculated with F II from apple and 37 with the organism carried as *F roseum,* F XVIII from wheat. Three buds of Lady Bountiful and 5 of Windsor were inoculated with F II from apple. June 6, 10 days after inoculation, 24 of the 30 buds inoculated with F II showed rot, all of the Lady Bountiful had rotted, 3 of the 5 Windsor had decayed. Of the 37 buds inoculated with F XVIII, 25 were destroyed by the fungus.

June 12, 1911, 24 buds were inoculated with material of the fungus, F XXIV, from June grass from a bean pod culture 3 days old, 22 buds with material from a potato cylinder culture 5 days old of the fungus, with obovate spores, F IX, from potato, 15 buds with material from a potato cylinder culture 5 days old of the fungus, F XIII, from sunflower, and check punctures were made in 10 other buds, June 21, 9 days later, 22 of the 24 buds inoculated with the fungus from June grass were decayed and all of the 15 buds inoculated with the fungus from sunflower were destroyed by the fungus. None of the 22 buds inoculated with the fungus from potato and none of the 10 checks showed any rot.

The fungus, F XXVI, isolated from quack-grass was used July 7, 1911, in making inoculations of 7 Enchantress, 6 Lady Bountiful and 12 Windsor buds. July 21, 6 of the 7 Enchantress, 5 of the 6 Lady Bountiful and 10 of the 12 Windsor were rotted. Examination of material from some of these showed the presence of many spores of both the septate and obovate types.

Eleven Enchantress, 7 Lady Bountiful and 12 Windsor buds were inoculated July 25 with material of the fungus, F XXV, from red top. Two weeks later, 8 of the 11 Enchantress, 5 of the 7 Lady Bountiful and 9 of the 12 Windsor were decayed.

The fungus from fowl meadow grass, F XXVII, which is identical in appearance in culture with the fungi from the other grasses was used September 27, 1911, in making inoculations of 16 Enchantress, 6 Lady Bountiful, and 6 Windsor buds. None of these buds decayed.

The fungus, F XXX, isloated from culms of timothy collected in Maine was used August 11, 1911, in making inoculations of 3 Lady Bountiful, 2 Enchantress and 15 Windsor buds. Ten days later 2 Lady Bountiful, 1 Enchantress and 7 Windsor buds were decayed. Great numbers of spores of the obovate form were found but there was no evidence of the presence of any other fungus.

November 21, 1911, 27 Enchantress, 15 Windsor, and 7 Lady Bountiful buds were inoculated with F IV from apple. Two weeks later, 22 of the Enchantress, 7 of the Windsor and 5 of the Lady Bountiful buds were rotted. This fungus had been carried in culture for about 2 years but still remained actively parasitic.

The fungus from corn, F XXXVI, which was designated Fusarium I by Burrill and Barrett was received from Dr. Barrett in November, 1911. December 13, 7 Enchantress, 6 Lady Bountiful and 8 Windsor buds were inoculated using material of this fungus from a potato cylinder culture 12 days old. None of these buds decayed.

The results of the rather large number of inoculations with fungi from different sources would indicate that a bud rot of carnations very similar to that described as due to *S. poae* may be caused by a number of different fungi some of which at least are typical species of Fusarium. A number of fungi which produce obovate and septate spores and agree in cultural characters with the carnation bud rot fungus were tested and most of these caused the rot. Three strains which appear to be very closely related to the carnation bud rot fungus in morphological and cultural characters failed to cause the rot. These were the fungus isolated from potato tuber, F IX, the one from fowl meadow grass, F XXVII, which is identical in appearance with the strains from the other grasses and the fungus from corn sent from Illinois by Dr. Barrett. Whether the failure of these fungi to cause the rot was due to the conditions at the time of inoculations or to the fact that these strains were not pathogenic to the carnation bud might be open to question. However, this point seems to have been determined rather definitely by inoculating a number of buds of the same variety with very similar fungi from different sources at the same time. The experiment of June 12, 1911, will illustrate this. The fungi used were the strain from June grass, F XXIV, which seems to be identical with *S. poae* as described by Stewart, the fungus with obovate spores from potato tuber, F IX, and the fungus from sunflower, F XIII. The material for all of the inoculations was taken from young actively growing cultures. Nine days after inoculation 22 of the 24 buds inoculated with the fungus from June grass and all of the 15 buds inoculated with the sunflower fungus were decayed. None of the 22 buds inoculated with the potato fungus showed any rot. Since the carnations were all of the same variety, Enchantress, and the different lots were growing side by side in the greenhouse, the fungus from potato had the same conditions for the attack of the buds as the other 2 fungi and the only conclusion which the writer can reach from the results is that the patoto fungus is not parasitic on carnation buds. This fungus resembles the carnation bud rot fungus more closely than do a number of other fungi which caused a rot of the buds. The fact that 2 other strains which are so like the fungus from June grass that it is impossible to distinguish cultures of one from the others failed to cause the rot of the buds would seem to indicate that certain strains are unable to go from one host to another. The most striking example of this was the fungus from fowl meadow grass, F XXVII. This fungus seemed identical in cultural characters with the strains from other grasses and yet it failed to cause the rot of carnation buds while the other strains caused the rot in a rather large proportion of the inoculations.

In his first account of carnation bud rot, Heald regarded a species of Fusarium as the cause of the disease. In his later publication, the fungus described was identical with the one described by Stewart as *Sporotrichum poae* and it was regarded as *S. anthophilum* which Stewart proved to be the same as *S. poae.* The inoculation experiments reported in this paper prove conclusively that a number of typical species of Fusarium cause a rot of carnation buds upon inoculation. Therefore, it is possible that Heald worked with different fungi, one a typical

Fusarium and the other the fungus with both obovate and septate spores, or it may be possible, as Stewart believed, that Heald's fungus showed at one time a predominance of septate spores and at another time of obovate spores and in that way led Heald to classify it at one time as Fusarium and later as a Sporotrichum.

The writer has found 3 types of fungi capable of causing the rot: first those with a predominance of obovate spores, as in the fungus from June grass, F XXIV; second, those which produce large numbers of both obovate and septate spores as in F II from apple and the fungus from sunflower, F XIII; and, third, certain typical species of Fusarium which produce no obovate spores as F I from apple and the fungus carried as *F. roseum,* F XVIII, from wheat. From the results of his inoculation experiments and culture studies Stewart concluded that his carnation bud-rot fungus, the fungus from June grass, and Heald's carnation fungus were identical. This conclusion is probably correct, yet attention should be called to the fact that emphasis should be placed on the cultural and morphological characters as well as on the results of inoculations because it has been shown that a number of species which are quite distinct in morphological characters may cause the rot of the buds.

The fact that a number of species or strains from different sources may cause the rot makes the question of control a more difficult one than it would be if only one fungus were responsible for the trouble. Heald regarded the bud rot as serious only in neglected houses while Stewart reported cases in which considerable loss occurred in houses which were well cared for. The fact that the fungi which cause the rot attack no other part of the plant than the interior of the bud would seem to indicate that in order to reach this part the fungus would have to enter through a wound in the calyx. In the greenhouse where the inoculation experiments reported in this paper were carried on, decay of buds which had not been inoculated was of very rare occurrence. In a very few instances, check buds in which punctures had been made were attacked by the fungi. The writer believes that as a rule in houses where every precaution is taken to remove and destroy material which might carry infection and where good conditions for growth are maintained there will be little trouble from the attacks of these fungi.

When it is considered that a vast number of spores may be produced on one diseased bud the necessity for great care in this work becomes apparent.

SUMMARY.

Species of Fusarium occur on a large number of host plants. A part of these fungi are destructive parasites. Owing to the confused condition or the classification of the species of this genus it is frequently difficult to distinguish a parasitic species from a saprophyte which has some similar characteristics. In many cases the same fungus has been described under a number of different names. In order to compare the fungi from different sources, it is necessary to grow them in culture under the same conditions. However, there is a wide difference in the value of different media for this purpose. Liquid media and agars give an abnormal growth as compared with the growth of the fungus on more favorable media such as cylinders of vegetables and other plant parts. Wollenweber * considers stems of plants the best medium for normal development of species of Fusarium.

In order to determine the extent of the parasitism of a given species it is necessary to carry out inoculation experiments. In some cases the same morphological species occurs on more than one host plant and it is only by inoculations that the question can be answered as to whether the strains occurring on one host can cause disease in another.

Two species of Fusarium have been isolated from Maine apples and it has been found that each of these is capable of causing decay. One of these, F I, agree quite closely with the organism received as *F. putrefaciens*, and which was described by Osterwalder as a cause of apple decay in Europe. The same fungus was isolated from diseased glumes of wheat, F VIII, and from potato stem, F XXXVIII. These strains also caused rot of apple fruit upon inoculation. One of the species, F II and F IV, from apple produces obovate spores similar to conidia of Sporotrichum in addition to typical septate Fusarium spores. This fungus resembles very closely in cultural characters the fungus which was described as the cause of a rot of carnation buds under the name *Sporotrichum poae* by Stewart. The chief difference is in the larger proportion of septate spores in the apple fungus. Similar strains have been isolated from a number of other hosts. All of these except one strain from sunflower, F XIII, and one from ears of flint corn, F XLIX, agree closely with the carnation bud-rot fungus in the proportion of septate and obovate spores. The strain from apple and the one from sunflower cause a rot of carnation buds which is identical with that caused by a strain from June grass which appears to be identical with the fungus described by Stewart. The writer believes that all of the strains which have both obovate and septate spores mentioned in this paper are closely related and that they constitute a group of species, each of which has strains occurring on a number of hosts. These fungi seem to be closely related to Fusarium in cultural characters and in being parasitic on plants. The chief difference between the form from apple and the one from June grass is in the proportion of septate spores. A fungus from summer squash, F XXXI, produces a few obovate spores in culture but the proportion is much less than in the form from apples. Thus there can be built up a series extending from strains in which most of the spores are of the septate Fusarium type with a few obovate spores to those with a small proportion of septate spores. Such a fungus as the one from summer squash would seem to be properly classified in the genus Fusarium but the other forms with the two types of spore are so similar to this one in cultural characters that all seem so closely related as to comprise a group. It may be possible that this group of species should be placed in another genus but after growing certain strains in comparison with species of Fusarium for a long period of time on a number of culture media the writer believes that the fungi with both septate Fusarium spores and obovate spores show closer relationship to Fusarium than to any other genus.

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* Wollenweber, H. W. Studies on the Fusarium Problem. Phytopathology 3 : 25, 1913.

Inoculation experiments proved that strains of the fungi with obovate spores from a number of hosts as well as certain typical species of Fusarium cause a rot of carnation buds which seem identical with the disease described by Stewart and by Heald as due to Sporotrichum. Since the inoculation experiments show that not all the species or strains are confined to a single host plant in their parasitism, a large amount of work in cross inoculation experiments will be necessary in determining the extent to which each species may cause disease.

CONCLUSION.

Plant pathologists have felt the need of a comprehensive piece of work in which species of Fusarium from a large number of sources would be grown in culture under uniform conditions so that their classification could be based on the characteristics brought out in the cultures. In 1910 the first part of a monograph of this genus, based on this method, was published by Appel and Wollenweber.* By their methods of culture, what they consider normal development is secured and cultures from different sources can be compared.

Later, in the winter of 1911, Dr. Wollenweber came to this country to study American forms. Realizing the importance of this work, the writer turned over to him transfers from cultures of 35 strains from various sources in February, 1912. These are being studied in culture according to Dr. Wollenweber's methods and it is expected that matters of interest in regard to their classification will be included in a part of the monograph to be published later.

It was hoped both by Dr. Wollenweber and the writer that part or all of the strains would be classified in time so that the names could be included in this paper, but on account of other work only a limited amount of time could be given to these cultures and for that reason Dr. Wollenweber made only a preliminary report on the classification of a part of the fungi.

APPENDIX.

Shortly after Dr. Lewis severed his connection with this Station Dr. Wollenweber made a more detailed report of his conclusions with regard to the relationship of the cultures of the various strains of Fusarium which had been received by him from Maine. Since Dr. Lewis' paper had been written up largely from the standpoint of the data obtained from his own studies and independent conclusions it would, in a measure, destroy its individual value as well as tend to obscure the important features of Dr. Wollenweber's report were the latter to be incorporated within the body of the former. Moreover to do this would necessitate making an entire recast of the article which for several reasons is impracticable and would lead to still farther delay in publication. Therefore, it seemed best to include this report in the form of the following tables, along with certain explanatory matter and comments, as an appendix to the original paper.

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* See foot-note p. 209.

Attention is called to the fact that Dr. Wollenweber has determined the species without knowing the results of Dr. Lewis' studies on their pathogenicity. Only a list of the hosts from which the species were isolated was furnished when the original pure cultures were delivered to him for determination. As will be seen in the discussion following the table most of the species are already described or have been mentioned in the literature upon the subject. In case complete descriptions are lacking he will include them in his monograph or some other publication in the near future. He has very kindly consented to this preliminary publication of the names previous to the final and more complete description. However characters considered to be important for the differentiation of new forms and new combinations have been furnished by him and are briefly discussed in the following pages.

LIST OF SPECIES OF FUSARIUM AS DETERMINED BY DR. WOLLENWEBER.†

F I	1171	*F. pirinum* (Fries) Sacc.	Apple fruit
F II	1172	*F. helianthi* Sacc. (s. var.)	“ “
F III	1173	*F. pirinum*	“ “
F IV	1254	*F. helianthi*	“ “
*F V			Sweet corn
F VI	1269	*F. poae* (Peck) n. n.	“ “

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† In the above list the Roman numerals preceded by the letter F designate the names under which the different strains or cultures of Fusarium are carried in this laboratory. The second and third columns give Dr. Wollenweber's serial, laboratory number and his determination of all the cultures sent him, with two exceptions, F X and F XI. The last column gives the source from which each culture was obtained. Those marked (*) were not sent to him. Attention is called to the fact that F XII, F XV (including F XVI), and F XVIII, received by and carried in this laboratory as *F. putrefaciens* Osterwalder, *F. oxysporum* Smith and Swingle, and *F. roseum* Lk. and referred to by these names throughout his paper by Dr. Lewis are designated as *F. pirinum* (Fries) Sacc., *F. orthoceras* App. and Wr., and *F. reticulatum* Mont. by Dr. Wollenweber.

F VII	1260	*F. orthoceras* App. & Wr.	Cucumber
F VIII	1272	*F. metachroum* App. & Wr.	Wheat
F IX	1247	*F. poae*	Potato tuber
F X	1252	(Not determined)	Apple fruit
F XI	1253	(Not determined	" "
F XII	1255	*F. pirinum*	" "
F XIII	1250	*F. helianthi*	Sunflower
F XIV	1251	*F. conglutinans* Wr.	China aster
F XV	1242	*F. orthoceras*	Potato tuber
F XVI	1243	*F. orthoceras*	" "
F XVII	1270	*F. discolor* var. *majus* n. var.	Dent corn
F XVIII	1273	*F. reticulatum* Mont	Wheat
F XIX	1259	*F. reticulatum*	Cucumber
F XX	1261	*F. argillaceum* (Fries) Sacc.	"
F XXI	1248	*F. citrinum* n. sp.	Tomato
* F XXII			"
F XXIII	1256	*F. reticulatum*	Squash
F XXIV	1268	*F. poae*	June grass
F XXV	1265	*F. poae*	Red top
F XXVI	1266	*F. poae*	Quack grass
F XXVII	1267	*F. poae*	Fowl meadow grass
F XXVIII	1262	*F. poae*	Timothy
F XXIX	1264	*F. reticulatum*	"
F XXX	1263	*F. poae*	"
F XXXI	1258	*F. helianthi*	Summer squash
F XXXII	1249	*F. orthoceras*	Garden pea stems
F XXXIII	1244	*F. solani* (Mart.) App. & Wr.	Potato tuber
F XXXIV	1245	*F. conglutinans*	" "
F XXXV	1246	*F. helianthi*	" "
F XXXVI	1271	*F. poae*	Dent corn
* F XXXVII			Apple fruit
* F XXXVIII			Potato stems
* F XXXIX		(Received as *F. vasinfectum* var. *pisi* van Hall)	
F XL	1257	*F. culmorum* (W. Sm.) Sacc.	Squash
* F XLIV			China aster
* F XLV			" "
* F XLVI		(Received as *F. niveum* Smith)	
* F XLVII			Apple fruit.
* F XLVIII			Flint corn
* F XLIX			" "

According to their relationships Dr. Wollenweber has arranged these species in sections of the genus as follows:

Section Martiella: *F. solani, F. argillaceum.*

Section Elegans: *F. orthoceras, F. conglutinans, F. citrinum.*

Section Discolor: *F. discolor* var. *majus, F. culmorum, F. reticulatum.*

Section Roseum: *F. pirinum, F. metachroum, F. helianthi.*

Section Sporotrichella: *F. poae.*

Dr. Wollenweber makes the following comments with regard to certain species.

"*F. culmorum* W. G. Smith is identical with *F. rubiginosum* App. and Wr.

F. citrinum is a new species, differing from *F. orthoceras* App. and Wr. mainly in the absence of a blue color but the presence of a citric color of the mycelium thallus grown on sterilized potato tuber.

F. discolor var. *majus* is a variety of *F. discolor* App. and Wr. having larger conidia and a higher average septation. This variety needs further study as well as *F. argillaceum, F. reticulatum, F. pirinum* and *F. helianthi.* The latter species described as *F. roseum* var. *helianthi* by Saccardo is interesting by the presence of a pyriform microconidial stage, which shows some relation to the corresponding stage of *F. poae.*

The rest of the species have been partly described in Appel and Wollenweber, Grundlagen einer Monographie der gattung Fusarium, 1910, and partly by the latter author in 'Studies on the Fusarium Problem.' Phytopathology, 1913. In this latter paper the sections mentioned above are given with the exception of Sporotrichella, which might be provisionally established for species with small globose to pyriform but also sickle-shaped, septate conidia of the type of *F. poae* (= *Sporotrichum poae*)."

In studying the combined results of these investigations two interesting facts are presented. First it is apparent that in some instances quite a number of different forms or species of Fusarium have been found associated with the diseased tissues of the same host plant, and second that some are quite omnivorous in their habits and occur upon several hosts. Since the great majority of the species of this genus are saprophytes or are at most wound parasites these observations are by no means new or novel. However, these facts may be of considerable importance from an economic standpoint and they are much more apparent when the strains of Fusarium studied are arranged in the form of a host index and in the form of a list which gives the number of different hosts from which the same strain was isolated or in which it was found capable of causing disease upon inoculation.

Host Index.

Apple fruit, (*Pyrus malus* L.)
    F. pirinum, F. helianthi (sub var.)
China aster, (*Callistephus hortensis* Cass.)
    F. conglutinans.
Dent corn, (*Zea mays* L.)
    F. discolor var. *majus, F. poae.*
Flint corn, (*Zea mays* L.)
    F. poae, (F XLVIII and XLIX, not studied by Dr. Wollenweber).
Sweet corn, (*Zae mays* L.)
    F. poae.
Cucumber, (*Cucumis sativus* L.)
    F. orthoceras, F. reticulatum, F. argillaceum.
Fowl meadow grass, (*Poa triflora* Gilib.)
    F. poae.
June grass, (*Poa pratensis* L.)
    F. poae.
Quack grass, (*Agropyron repens* (L.) Beauv.)
    F. poae.
Red top, (*Agrostis alba* L.)
    F. poae.
Timothy, (*Phleum pratense* L.)
    F. poae, F. reticulatum.
Pea, (*Pisum sativum* L.
    F. orthoceras.
Potato (*Solanum tuberosum* L.)
    F. poae, F. orthoceras, F. solani, F. conglutinans, F. helianthi, F XXXVIII. (The latter not studied by Wollenweber but according to Lewis is identical with *F. pirinum.*)
Summer squash (*Cucurbita pepo* L.)
    F. helianthi
Winter squash (*Cucurbita maxima Duchesne*)
    F. reticulatum, F. culmorum.
Sunflower (*Helianthus annuus* L.)
    F. helianthi
Tomato (*Lycopersicon esculentum* Mill.)
    F. citrinum.
Wheat (*Triticum sativum Lam.*)
    F. metachroum, F. reticulatum.

List of Species Giving Hosts from Which They Were Isolated and Summary of Inoculation Tests.

F. argillaceum (Fries) Sacc., from cucumber.
    Produced decay of cucumber on inoculation.
F. citrinum nova species, from tomato.
F. conglutinans Wr. from china aster and potato.
    Caused decay of cucumber but not of apple fruit (?).

F. culmorum (W. Sm.) Sacc., from winter squash.
Caused decay of cucumber fruits.

F. discolor var. *majus* nova var., from dent corn.

F. helianthi Sacc. (sub var.) from apple fruit, potato, summer squash and sunflower.
Produced decay of carnation buds, also fruits of apple and pear. Negative results with strain from apples on potato tubers.

F. metachroum App. and Wr., from wheat.
Caused decay of apples.

F. orthoceras App. and Wr., from cucumber, pea and potato.
Positive results from inoculation of apple and cucumber fruits, negative upon carnation buds.

F. pirinum (Fries) Sacc., from apple fruit. (F XXXVIII from potato considered identical with *F. pirinum* by Lewis.)
Positive results from inoculations upon apple and pear fruits and carnation buds. Negative upon potato tubers.

F. poae (Peck) novum nomen, from dent, flint and sweet corn, fowl meadow grass, June grass, quack grass, red top, timothy and potato tuber.
Positive results from the inoculation of carnation buds with the strains from June grass, quack grass, red top, and timothy.

Negative results upon carnation buds from the strains from fowl meadow grass, dent corn and potato. Strain from sweet corn caused decay of cucumber fruit.

F. reticulatum Mont., from cucumber, winter squash and wheat.
Positive results from inoculation of carnation buds and cucumber fruits.

F. solani (Mart.) App. and Wr., from potato.

The object of the summary of the inoculation tests is simply to assemble in condensed form the more important data secured by Dr. Lewis regarding pathogenicity and align it as far as possible with the names of the different species to which Dr. Wollenweber has referred the various strains of Fusarium under consideration. Mention should be made, however, of the fact that with the possible exception of *F. conglutinans* all of the strains studied produced some decay of some varieties of apples. However, only those which gave constant and marked positive results are so credited in the summary. The details of the inoculation tests will be found on pages 239-251.

W. J. M.

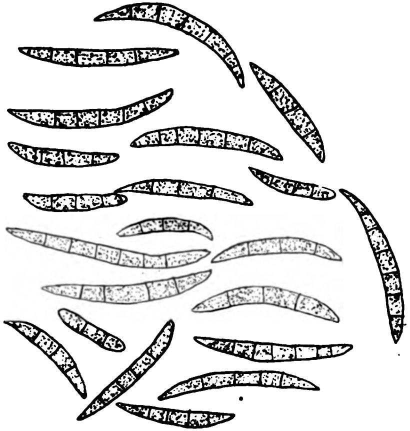

FIG. 86. Spores of F I (*F. pirinum*) from apple, from a potato agar plate culture 3 weeks old. x 480.

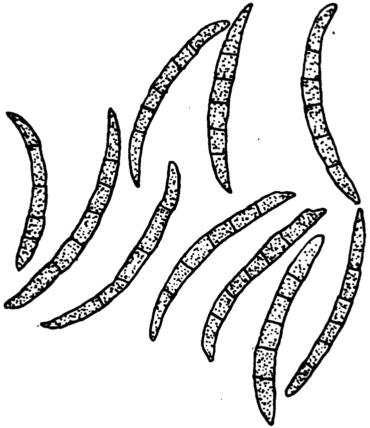

FIG. 87. Spores from a strain of F I (*F. pirinum*) isolated from Milden apple. Spores from sporodochia from a young bean-pod culture. x 480.

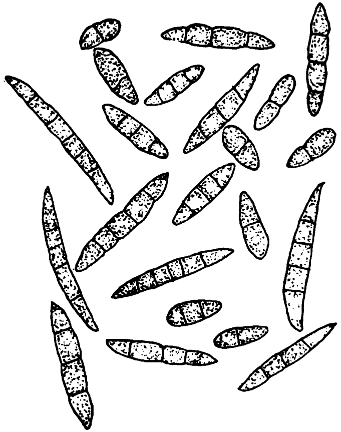

FIG. 88. Spores of F III (*F. pirinum*) from apple, from a potato agar plate culture 3 weeks old. x 480.

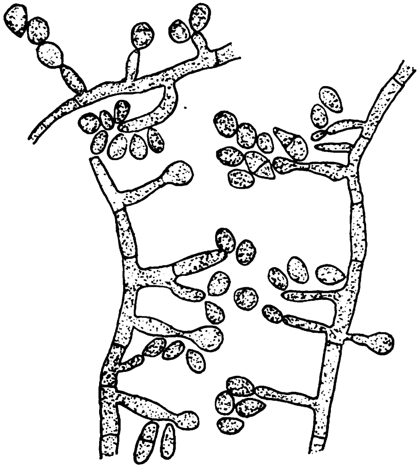

FIG. 89. Obovate spores of F IV (*F. helianthi*) from apple, showing the manner in which they are formed. From a hanging drop culture in one per cent saccharose broth. x 480.

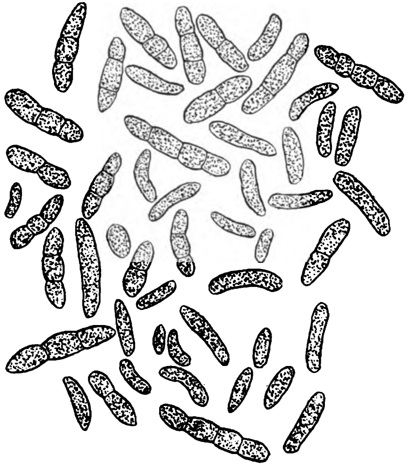

FIG. 90. Spores of F IV (*F. helianthi*) from apple, from a prune agar culture 5 days old. x 480.

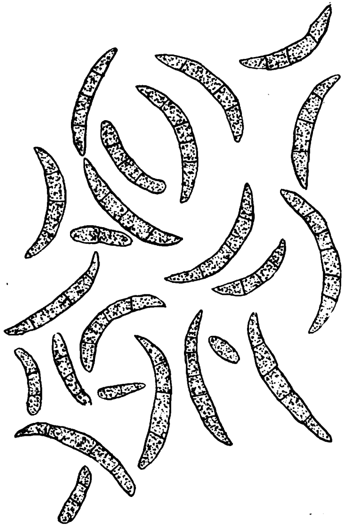

FIG. 91. Spores of F IV (*F. helianthi*) from a potato agar plate culture 3 weeks old. x 480.

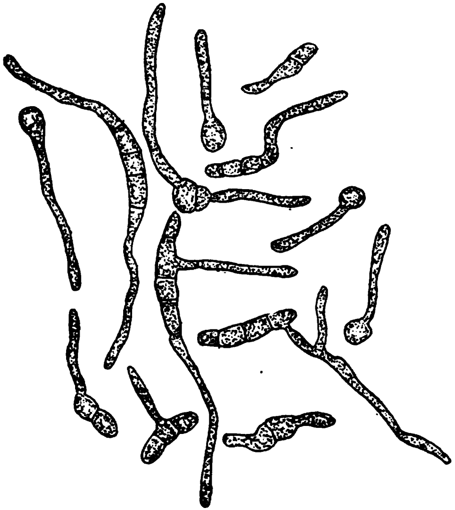

FIG. 92. Germinating spores of F II (*F. helianthi*) from apple after 4 to 6 hours in hanging drop of apple wood decoction. Obovate one-celled, pyriform 2-celled, and septate spores of the Fusarium type are shown. x 480.

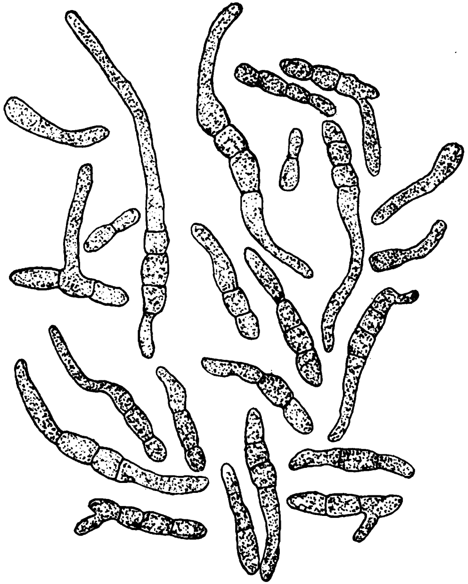

FIG. 93. Germinating spores of F IV (*F. helianthi*) after 5 to 7 hours in one per cent saccharose broth. x 480.

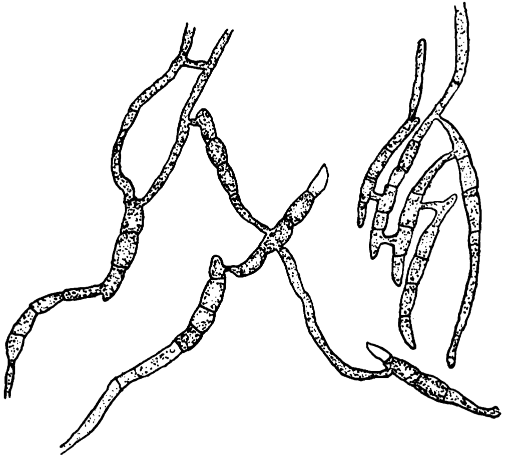

FIG. 94. Germinating spores of F I (*F. pirinum*) showing fusions after 24 hours in hanging drop of apple wood decoction. x 480.

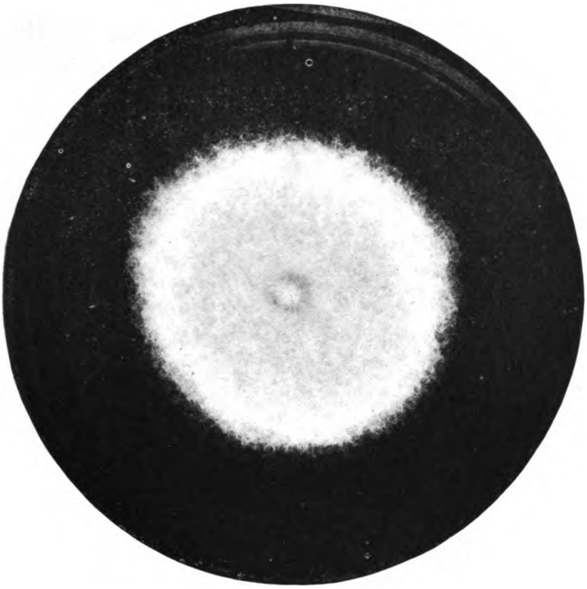

Fig. 95. F II (*F. helianthi*) from apple. Culture 4 days old on synthetic agar.

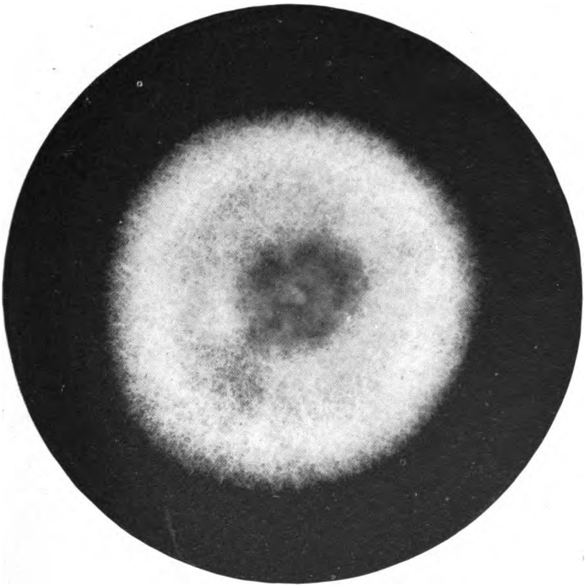

Fig. 96. F XIII (*F. helianthi*) from sunflower. Culture 4 days old on synthetic agar.

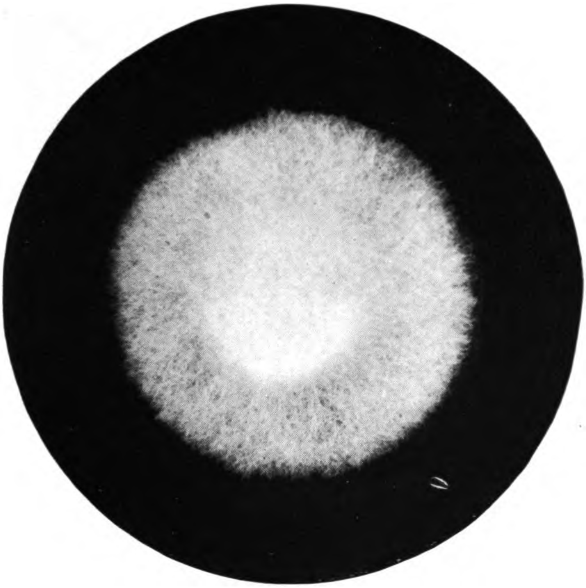

FIG. 97. F XXIV (*F. poae*) from June grass.
Culture 4 days old on synthetic agar.

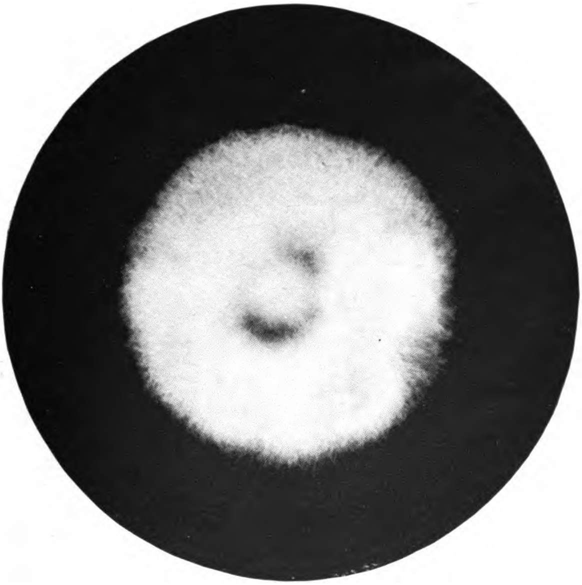

FIG. 98. F XXVI (*F. poae*) from quack grass.
Culture 4 days old on synthetic agar.

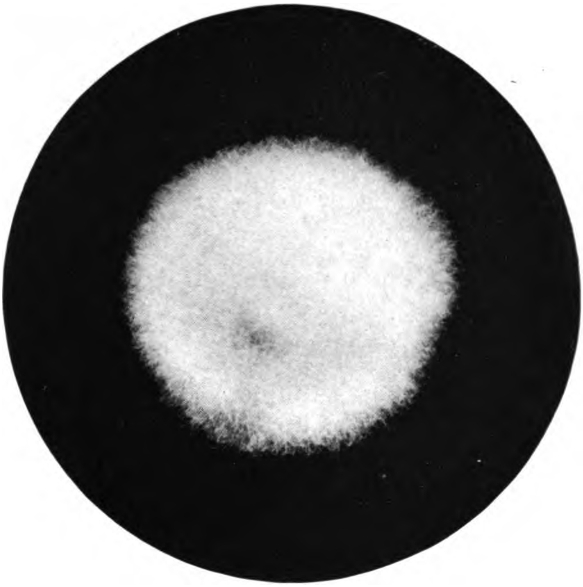

FIG. 99. F XXVIII (*F. poae*) from timothy.
Culture 4 days old, on synthetic agar.

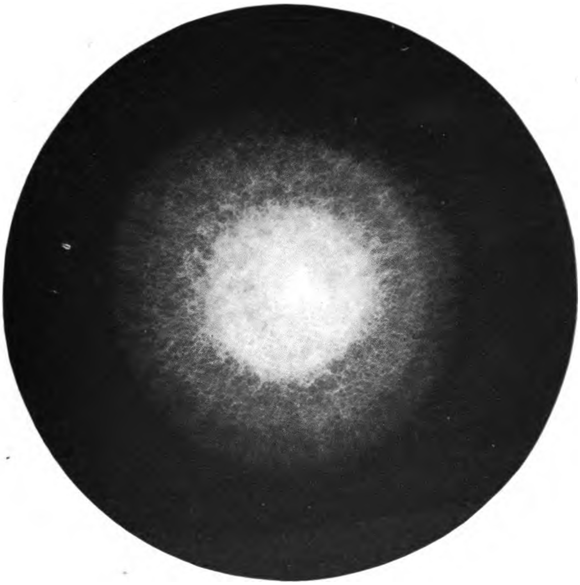

FIG. 100. F III (*F. pirinum*) from apple.
Culture one week old on synthetic agar.

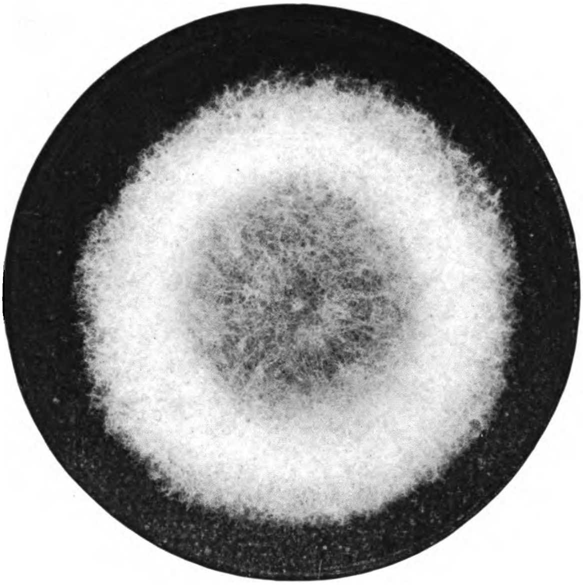

FIG. 101. F II (*F. helianthi*) from apple. Culture 5 days old on synthetic agar.

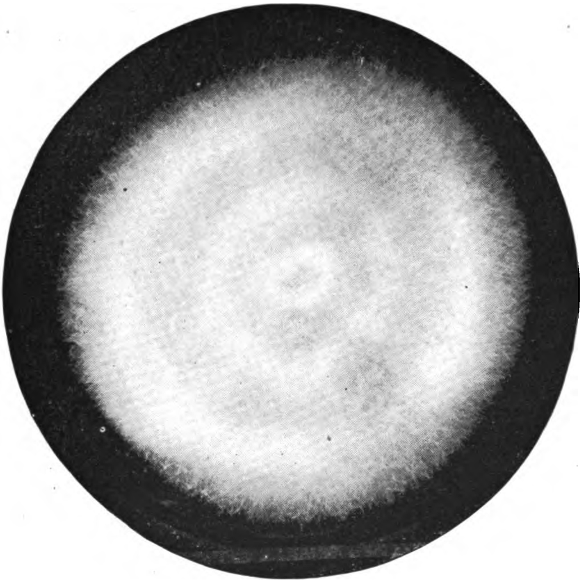

FIG. 102. F I (*F. pirinum*) from apple. Culture one week old on synthetic agar.

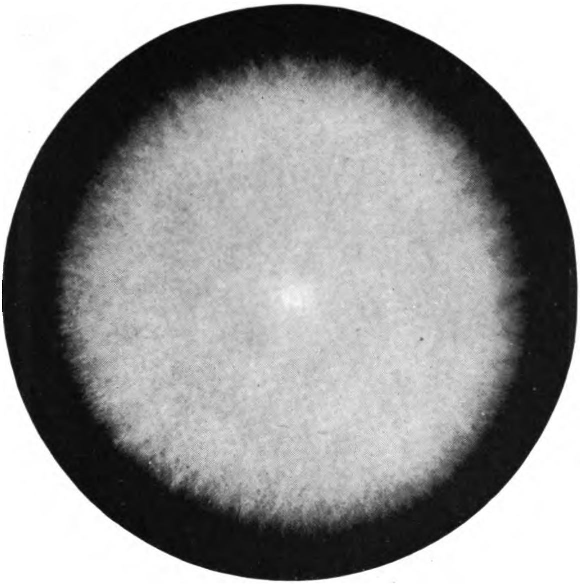

FIG. 103. F XV (*F. orthoceras*) from potato tuber from Vermont. Culture one week old on synthetic agar. This fungus was carried as *F. oxysporum*

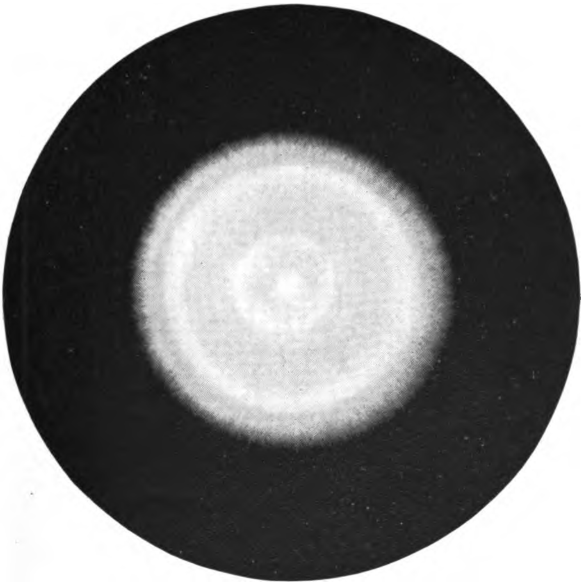

FIG. 104. F XX (*F. argillaceum*) from cucumber. Culture one week old on synthetic agar.

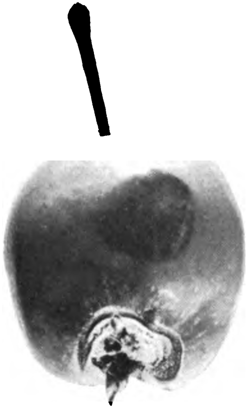

Fig. 105. Fusarium as it occurred on green apple on tree.

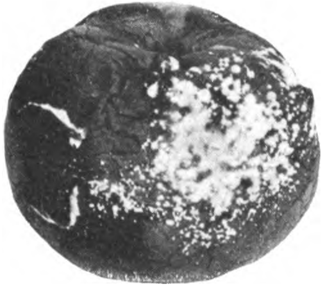

Fig. 106. F III (*F. pirinum*) on apple.

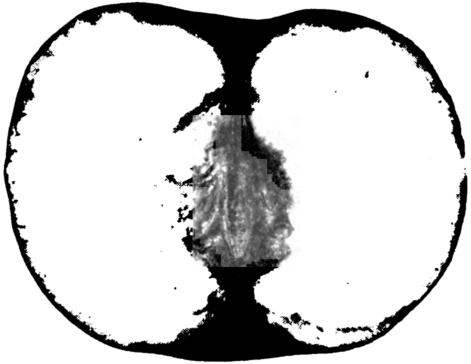

Fig. 107. Fusarium decay in core of apple.

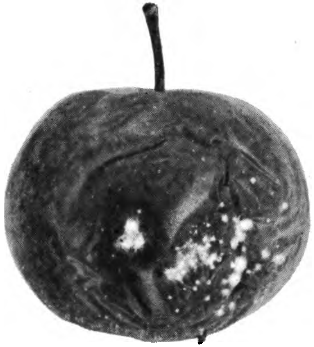

Fig. 108. Green apple 38 days after inoculation with F I (*F. pirinum*).

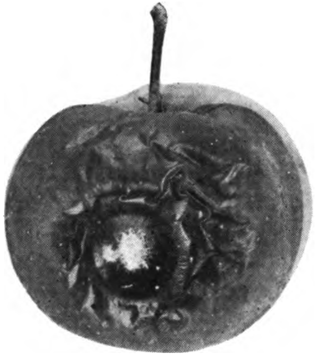

Fig. 109. Green apple 38 days after inoculation with F XII (*F. pirinum*).

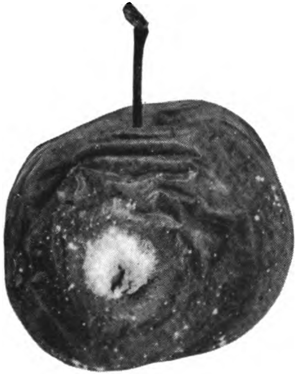

Fig. 110. Green apple 38 days after inoculation with F XV(*F. orthoceras*), which is referred to in the text as *F. oxysporum*.

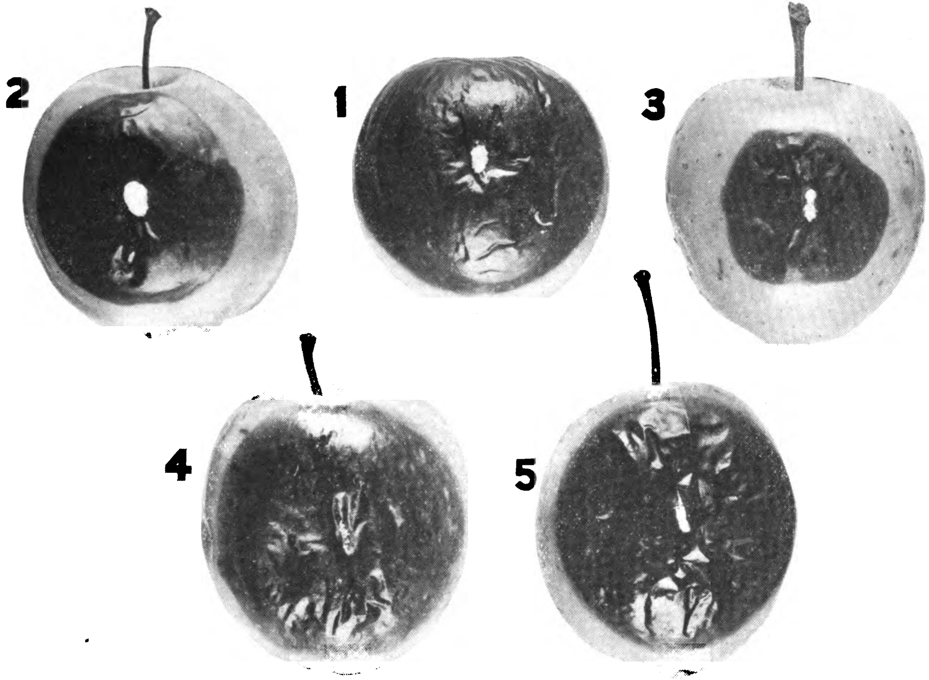

FIG. 111. Bellflower apples inoculated with Fusarium. 1 with F I, 2 with F II, 3 with F III, 4 with F IV, 5 with F XV.

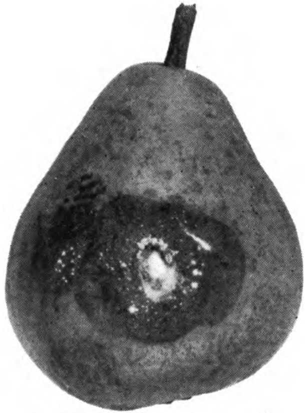

FIG. 112. Pear inoculated with F I (*F. pirinum*) from apple.

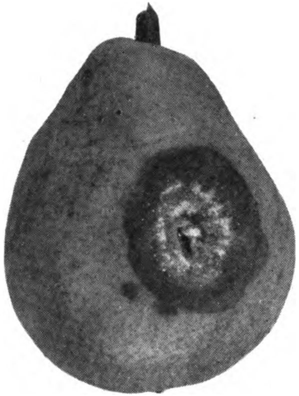

FIG. 113. Pear inoculated with F II (*F. halianthi*) from apple.

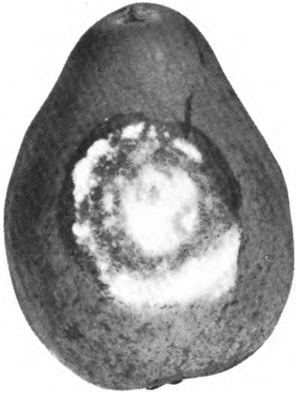

FIG. 114. Pear inoculated with culture received from Osterwalder as *F. putrefaciens* (*F. pirinum*, according to Wollenweber).

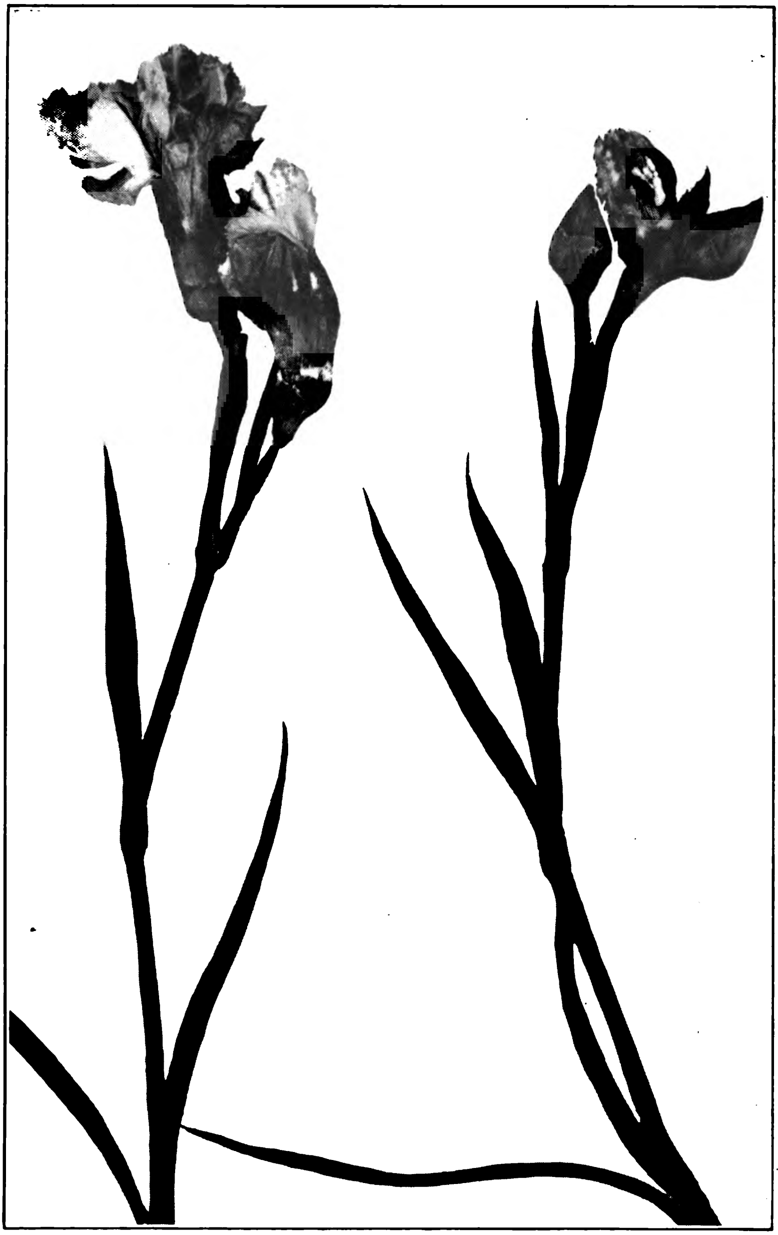

Fig. 115. Carnation bud-rot produced by inoculation with F II (*F. helianthi*) from apple.

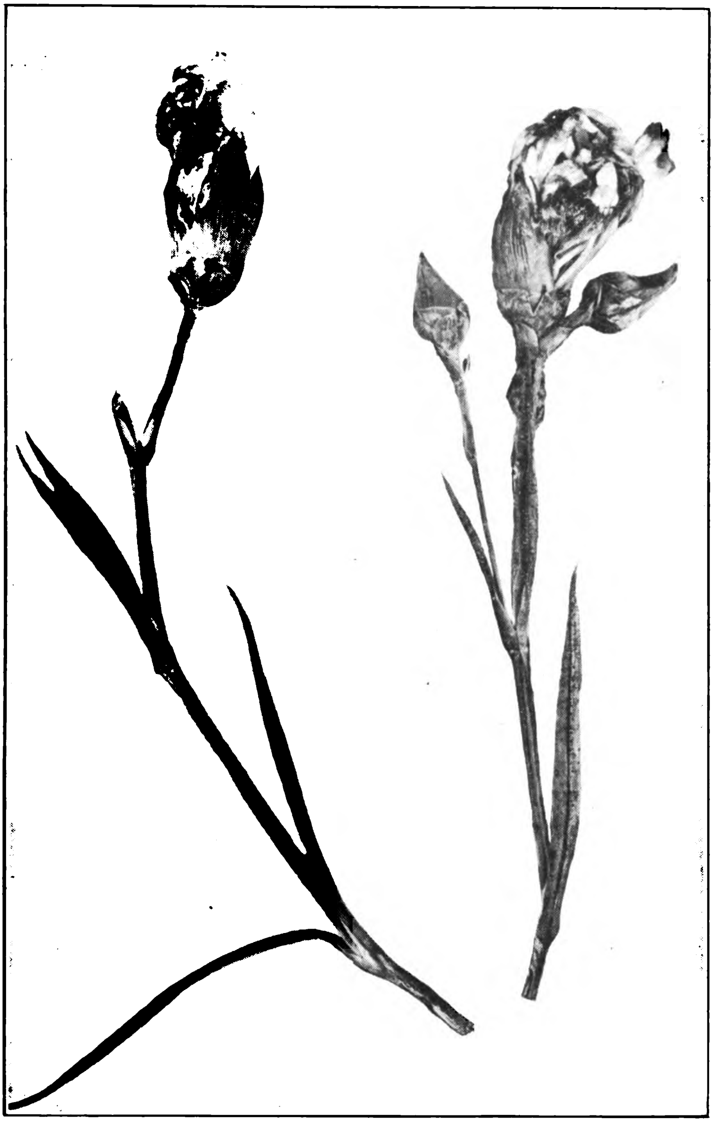

Fig. 116. Carnation bud-rot produced by inoculation with culture received as *F. putrefaciens*. (*F. pirinum*, according to Wollenweber).

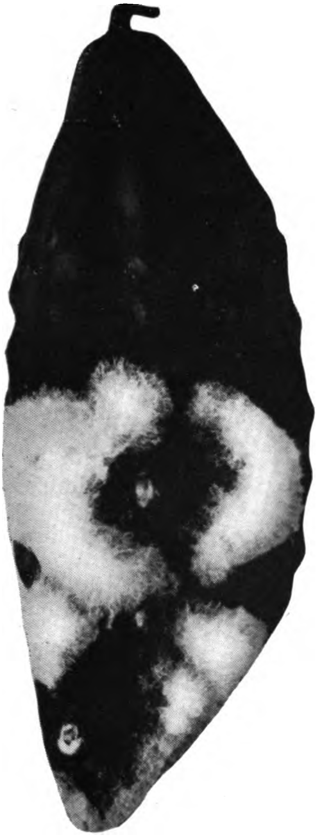

FIG. 117. Decay of cucumber produced by inoculation with F II (*F. helianthi*) from apple.

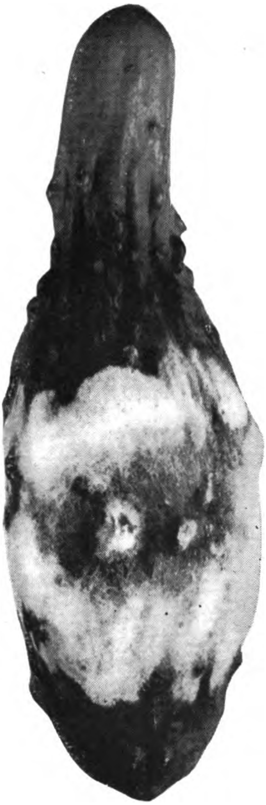

FIG. 118. Cucumber inoculated with F XIII (*F. helianthi*) from sunflower.

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ORONO

BULLETIN No. 220. NOVEMBER, 1913

WOOLLY APHIDS OF THE ELM

CONTENTS.

This bulletin contains a treatment of the elm aphids of Eastern United States belonging to the genus Schizoneura, accompanied by a list of aphids recorded from other parts of the world on certain plants including the elm.

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BULLETIN No. 220

WOOLLY APHIDS OF THE ELM.*

EDITH M. PATCH.

Since the publication of Bulletin 203 about one year ago, the elm aphids belonging to the genus *Schizoneura* have been making such rapid history that that publication is not only out of print but also out of date. It is the purpose of Bulletin 217 and the present paper to bring together what information I have on this group of elm aphids, more as a report of progress in order to clear away certain previous confusions than as an attempt at a complete treatment.

I have received very considerable aid in this study from entomologists in widely separated parts of this and other countries and express my appreciation of such help in general rather than in specific terms, not from any desire to assume credit for data worked in accordance with suggestions from others but in order that no one else need find himself made responsible for the manner in which these fragments are presented.

While it is to be regretted that we have not the total stories of all the species discussed it seems wise to bring the account up to date, trusting that the missing links will be forthcoming sometime, somewhere.

The present discussion takes no account of such species as have as yet been collected only in the far West as those can most fittingly be introduced by the entomologists who have been observing them at close range.

Among the points of specific value in separating these aphids are the antenna of the stem females with especial reference to the relative length of the joints, the wax glands of the apterous generations other than the stem mother, and the antennal characters of the winged females. The habitat and the species of the elm concerned are also of much significance.

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* Papers from the Maine Agricultural Experiment Station: Entomology No. 68.

The text figures of antennæ in this bulletin are all drawn to the same scale.

WOOLLY APHID OF ELM BARK.

(*Schizoneura rileyi.*)

It is not uncommon to find the trunks and branches of young elms with tender places in the bark closely packed with colonies such as are shown in Figure 140. That Riley was correct in describing this as a distinct species a further acquaintance with the aphids leads me to believe. The stem mother has joint III of antenna conspicuously shorter than those of the "leaf roll" or "rosette." The wax glands of the second generation are of a type similar to *lanigera* but with a tendency to a larger central area. The antenna of the winged forms has joint III with the annulations less symmetrical than the other elm *Schizoneurans,* and the grooves between the annulations are of more varying depths.

There are several matters of biological interest in connection with this aphid which set it apart from any other species I know at present. Winged forms are developed both in June and in August, but both are developed on the elm. Whether they have lost their function as migrants altogether, whether they simply take wing to other elms, or whether there is a kink in the total life cycle of this insect which we have not yet learned, I do not know.

On September 23, 1908, I made a collection of apterous viviparous forms which gave birth to the true sexes. As in this genus, so far as I know, the mothers of the sexual generation are in other cases winged this seems peculiar. Individuals were inclosed in vials with bits of cloth and the records carefully taken so there could have been no mistake.

The minute apterous oviparous females are born with a beak which is lost with the molt. They have a 5-jointed antenna. Total length of body 0.8 mm. This form lays but a single egg.

The apterous males are but 0.55 mm. long and their bodies are slender. Their antennæ and legs are relatively much longer than those of the female. Antennæ are 5-jointed. Mature male without beak, this being lost at molt. Described from specimens taken September 23, 1908. Maine collection number, 89-08.

Antennal drawings of different forms are given here for comparison with the other species.

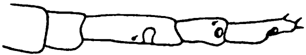

Fig. 119. The antenna of the stem mother of *rileyi* is distinguished at once from those of the curl and rosette dwellers by the difference in length, it being much shorter in this species. It is normally a 5-jointed structure but there is frequently a clear spot in III as shown in this figure which seems to be a vestigial indication of another joint. (52-13).

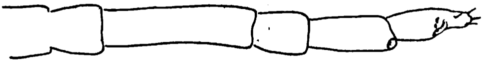

Fig. 120. Evidently a part at least of the second generation become winged as winged forms are present by the middle of June at which time the stem mother is still actively producing nymphs. The antenna of the pupa is given in this figure. (7-08). It is characterized by a rather short bulged IV.

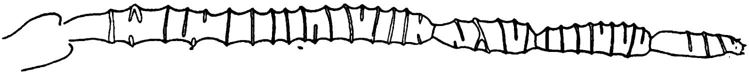

Fig. 121. The antenna of the spring winged generation is characterized by having wider spaces between the annulations on III than is usual for the curl and rosette dwellers, and with less symmetry as to the antennal grooves. Annulations are com-

mon on VI. The antenna of this generation is practically the same in appearance as that of the fall winged generation. (7-08).

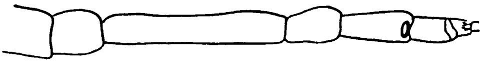

Fig. 122. The antenna of an apterous viviparous form giving birth to the true sexes. (89-08). The relative length of the joints are approximately the same as those of the pupa.

The following collection notes are perhaps worth keeping as a part of the discussion of this species:

Aphid 69-05. September 2, 1905. Present in great numbers in woolly clusters along trunk of small elms at Orono. Apterous viviparous form and nymphs. This material was determined by Mr. Pergande as *Schizoneura rileyi* during the winter of 1905-06.

Aphid 95-06. August 4, 1906. Orono. Apterous and alate forms present on trunk of young elm.

Aphid 7-08. June 16, 1908. Woolly mass on trunk of small elms. Winged viviparous forms just developing from pupæ.

Aphid 89-08. Sept. 23, 1908. Orono. Apterous viviparous forms in woolly bunches on trunk and branches of young *Ulmus americana,* causing knotty growth. The progeny of these apterous forms were the true sexes,—apterous oviparous females and apterous males. Eggs were plentiful under the bark.

Aphid 52-13. June 14, 1913, Orono. Colonies in tender places on trunk of young elms (*Ulmus americana*). Stem mothers, nymphs and pupæ.

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* No attempt has been made to give a complete bibliography for any species in this paper.

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1913. *Schizoneura* from elm bark. Patch Annals Ent. Soc. America. Plate 24, Figs. 19, 20, 21, 22.

A NEW ELM GALL FOR AMERICA.

Schizoneura lanuginosa?

A gall unlike any I have seen before was sent me last August from Connecticut by Doctor Britton. It was deserted and brown and dry, but as Figure 139C will show it resembles the pictures by Buckton of *lanuginosa* so closely that it seems probable that it is that species. The gall was apparently an out growth from the twig at the base of the petiole, resulting in the extreme dwarfing of the nearest leaves. It is figured here merely to call attention to the occurrence of such a gall in New England in hopes that specimens may be collected earlier another season before the migrants have taken wing.

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1909 (1910) *Schizoneura lanuginosa,* Henrich, Die Blattlause der Umgebung von Hermannstadt.

Elm Rosette or Leaf Cluster Aphid.

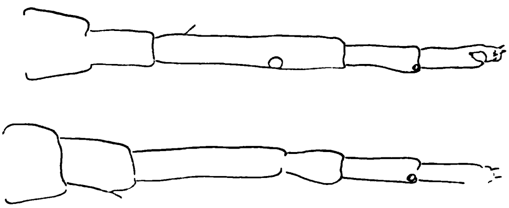
Schizoneura lanigera (*americana* in part of authors).

This aphid and the next succeeding are treated in Bulletin 217. I do not know whether the two are distinct, but from the appearance and the behavior of the summer generations of both on *Pyrus* and the antennal characters of the fall migrants do not feel that there is any basis of separating them except as to the nature of their elm habitat.

The antenna of different generations of the rosette aphid, (Figs. 123 to 128) together with some details as to wax glands (Fig. 143 D. J. K.) are given for comparison with the other elm aphids.

This migrates normally to *Pyrus* in Maine the spring migrants from the elm leaves settling on the under side of the leaves of mountain ash and apple, and their immediate progeny creeping to stems of water shoots or tender places in the bark before feeding. Such normal out of door colonies which were watched carefully during their origin are shown in Fig. 78 in Bulletin 217 of this Station. I have also reared the progeny of the spring migrants on mountain ash in confinement, such a colony being shown in Fig. 69 in Bulletin 217.

It is abundant in both Maine and Colorado and doubtless all the way between.



Figs. 123 and 124. Antennæ of stem mother from rosette. The antenna of this form is normally 5-jointed with a trans-parent place varying in shape and size on III that seems to be a vestigial indication of another joint. Indeed 6-jointed antennæ for this form are by no means rare and it sometimes happens that a specimen will have one 5-jointed antenna and the other distinctly 6-jointed. (33-13).

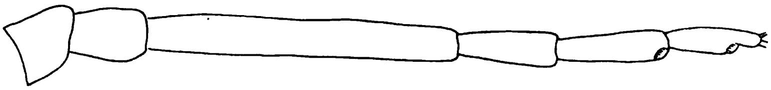


Fig. 125. The antenna of the rosette aphid, second generation, apterous viviparous. (33A-13). Typically this has III as long as or longer than IV+V+VI, and in this respect resembles the antenna of the winged form of this species.

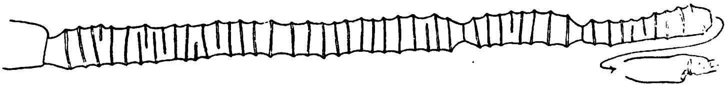
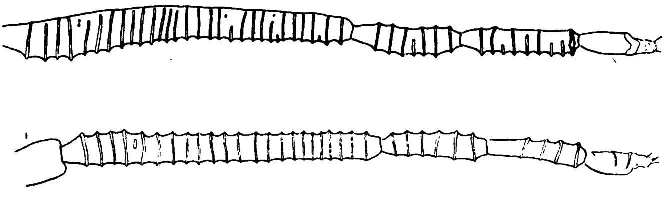


Fig. 126. Antenna of spring migrant from rosette,—one of the collection whose progeny colonized the seedling mountain ash as shown in Bulletin 217, Fig. 69. (57-13).



Figs. 127 and 128. Antennæ of spring migrants from rosette collected July 10, 1912, from under side of mountain ash leaf in the open where they were settled and producing progeny. (See Fig. 78, Bulletin 217) Ordinarily VI is without annulations but these sometimes are present as is shown in Fig. 128. (60-12).

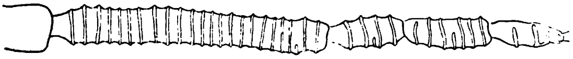


Fig. 129. Antenna of fall migrant collected from hawthorn, *Crataegus*. (114-06).

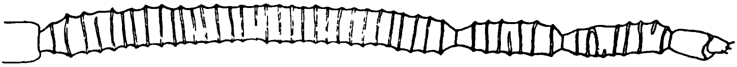


Fig. 130. Antenna of fall migrant collected from mountain ash. *Pyrus* sp. Typically VI is with two or more annulations, but these are sometimes lacking. (63-11).

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1900. *Schizoneura americana,* Lugger (in part). Bul. No. 69. Minn. Agr. Exp. Sta. Id. 6th Ann. Rept St. Ent. of the St. Exp. Sta. Univ. of Minn. p. 169. "If at all numerous they can greatly deform the ends of the twigs, where all the leaves are curled, forming a mass of sickly, yellowish leaves."

1904. *Schizoneura americana* (in part). Sanborn, Kansas Aphid. p. 25. "When numerous they give the leaves a whitish appearance and cause the terminal ones to bunch together, which gives the lice more protection."

1909. *Schizoneura ulmi* (*americana*). Gillette. Jour. Ec. Ent. Oct. Fig. 16. Antenna.

1910. *Schizoneura americana* (in part). Patch. Bul. 181. Me. Agr. Exp. Sta. Fig. 151.

1912. *Schizoneura lanigera* (*americana*). Patch, Woolly aphid migration from elm to mountain ash. Jour. Ec. Ent. pp. 395-398. Figure 2.

1912. *Schizoneura lanigera* (*americana* in part). Patch. Bul. 203. Me. Agr. Exp. Sta.

1913. *Schizoneura* sp. Gillette. 25th Ann. Rept. of the Col. Agr. Exp. Sta. p. 30, "the form producing the rosette like cluster of leaves at the tip of elm twigs."

1913. *Schizoneura* sp. Patch. Ann. Ent. Soc. Am. Figs. 68 to 82.
1913. *Schizoneura lanigera.* Patch. Bul. 217. Me. Agr. Exp. Sta. Figs. 69, 70, 71, 72, 78, 79, 80, 81.

SOUTHERN ELM LEAF CURL.

Schizoneura lanigera (*americana* in part of authors).

My acquaintance with this form is limited to material sent me from the south the spring of 1912. I am not sure of the species of *Ulmus* it was taken on, but think it was *americana.*

Photographs of the curl and the woolly colony on apple, bred from migrants of this form are given as Figures 67 and 68 of Bulletin 217.

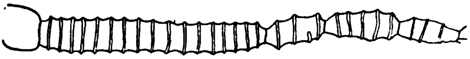

Fig. 131 represents the antenna of the fall migrant (*sexupara*) of the same bred colony. (9-12 sub. 1.)

It will be seen that this has the same characteristics as the corresponding form taken on *Pyrus* or *Crataegus* out of doors as shown in Figures 129 and 130. It is smaller than many of the out door grown individuals but the overstocked and dwarfed little seedling on which it developed may well be responsible for the size of the insects which were reared through the several generations from the spring migrants in confinement on the same potted apple in confinement.

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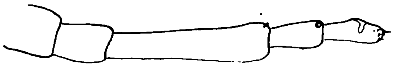
1912. *S. lanigera* (*americana*). Patch. Journal Economic Entomology Vol. 5, p. 396. (first paragraph of page).
1912. *S. lanigera* (*americana*), Patch. Bul. 203. Me. Agr. Exp. Sta. Top of page 237 and Fig. 448.
1913. *S. lanigera* (*americana*). Patch. Journal Economic Entomology. Vol. 6, pp. 316-318.
1913. *Schizoneura.* Patch. Annals Entomological Society America. Vol. 6, Plate 24. Fig. 11 and Plate 25. Fig. 27.
1913. *S. lanigera* (*americana* in part). Patch. Bul. 217. Me. Agr. Exp. Sta. Figs. 67 and 68.

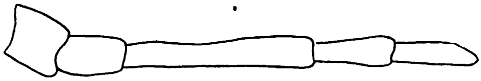
NORTHERN CURL OF AMERICAN ELM.

Schizoneura americana in part, of authors.

The popular name here applied to this species may be unfortunate as the same insect exists also in the south, but it is apparently the most common aphid in the northern states inhabiting the roll or curl type of leaf deformation on *Ulmus americana.*

The stem mother matures in Maine early in June, in the young roll. (Fig. 139A) At this time she is somewhat powdery but if removed from the curl and examined in sunlight with a lens her body is found to have a distinctly greenish cast. When mounted alive on a slide in balsam there is no dark reddish stain though the balsam may be slightly yellowed. This species may be distinguished by these signs from the rosette dweller which shows distinctly reddish in the sunlight and stains the balsam a deep red when mounted alive.





Figs. 132 and 133 show the antenna of this form which resembles that of the rosette species closely. Indeed the antennal joints of the first generation of both these species vary enough in different individuals to make this structure of little value in separating the curl and the rosette species in this stage. (32-13 and 32A-13).

The second apterous generations however, are readily distinguished by their wax glands, those of this curl dweller being arranged in an irregular rather elongate mass and not placed about a clear central area as in the case of the rosette dweller.

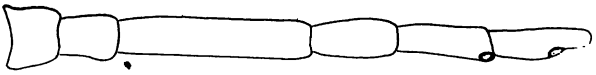


Fig. 134. The antenna of this generation is 6-jointed and distinguished from that of the rosette dweller in having III typically shorter than IV+V+VI. (32A-13.) This generation matures about June 17 in Maine.

Whether the migrant generation maturing late in June are altogether the progeny of the second apterous generation or in part the daughters of the stem mother I do not know. My field observations lead me to think that part of the progeny of the second apterous generation desert the elm leaves and settle under the scales of the elm bark in tender places on the trunk and there subsist as bark feeders in woolly colonies but less conspicuous and more hidden than *rileyi*. At any rate such bark colonies occur here in Maine for which I can not otherwise account.

The fact that the stem mother is still actively giving birth to nymphs for some time after the second apterous generation become mature and are producing young complicates the case considerably when an attempt is made to sort out the young. Figure 139B shows an old roll just deserted by the migrants.

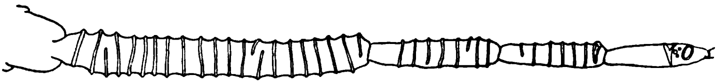


Fig. 135. The antenna of the spring migrant. It is typical for this structure to have III shorter than IV+V+VI and VI subequal to or even longer than V. The length of VI, however, is variable in Maine material and is apparently ordinarily a little shorter than with the same species as it occurs in the western states. The number of annulations on III is also subject to considerable variation. The antennæ of those individuals developing in leaf curl late after the leaf becomes less sappy are likely to differ very strikingly from those developing earlier in the season both in total length of antenna and in the number and distribution of the annulations, as is illustrated in Annals Entomological Society of America, Vol. 6, Plate 24. Figs. 2, 6 and 7 are all drawn to the same scale. Figs. 6 and 7 represent the antenna of individuals collected July 23, 1912 for comparison with specimens, Fig. 2 which developed June 30 in the same leaf rolls. The difference in the total size of the antennæ and in the

number of annulations of the big thrifty early ones from the juicy leaf and the last individuals to develop in the drying roll would seem suggestive of the physiological effect of the habitat on the size of the individual and the character of the antenna. (68-13.)

The migration of this winged generation from the leaf curl is a matter of frequent record and easy to observe. Where it goes and what the food plant of its summer progeny is still unknown. During 1912 a few individuals of this species were taken in the open on *Pyrus* leaves together with the rosette dweller, but a further acquaintance with the elm *Schizoneurans* leads me to believe that they had merely alighted there accidentally on the way to their proper host.

A fall migrant is found on the elm whose antenna accords with that of the spring migrant of this species and is probably the return migrant. Neither the spring nor fall winged forms have the antenna of *lanigera* and the wax glands of the second generation distinguish it from that *Ulmus-Pyrus* species.

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1879. *Schizoneura americana* in part, Thomas (in part). Report of the State Entomologist Ill. VIII, p. 202. Quotes Riley's description.

1887. *Schizoneura americana,* Oestlund, O. W., (in part). Aphid. Minn. p. 27. Description of winged form and pseudo gall.

1890. *Schizoneura americana* Packard, (in part). Fifth Rept. U. S. Entom. Com. p. 279. Extract from Riley Bul. U. S. Geol. and Geograph. Survey, Vol. V, No. 1.

1897. *Schizoneura americana,* Gillette, C. P., (in part?). Bul. Div. Ent. U. S. Dept. Agric. 9 (n. s.) : 78-79. Description of work.

1900. *Schizoneura americana,* Lugger, (in part). Bul. No. 69. Minn. Agr. Exp. Sta. Id. 6th Ann. Rept. St. Ent. of the St. Exp. Sta. Univ. of Minn. pp. 168, 169. Fig. 148 after Riley.

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1902. *Schizoneura americana,* Weed, C. M. Bul. No. 90. N. H. Agr. Exp. Sta. p. 37. Brief account and photograph of curled leaf.

1902. *Schizoneura americana,* Cook, M. T. Galls and Insects Producing Them. Ohio Naturalist. Vol. II, No. 7, p. 265 and Fig. 12. Discussion of structure of gall.

1904. *Schizoneura americana,* Sanborn, C. E. (in part). Kansas Aphid pp. 25-26.

1904. *Schizoneura americana,* Cooley, R. A. 10th Ann. Rept. Mont. Agr. Exp. Sta. pp. 43-45. Records this insect as a decidedly obnoxious pest in some parts of Montana on *Ulmus americana.*

1905. *Schizoneura americana,* Felt, E. P., (in part). N. Y. St. Mus. Memoir 8: pp. 172, 177-178. Description of leaf curl, and life history adapted from Riley.

1909. *Schizoneura ulmi* L. (*americana* Riley) Gillette, C. P. (in part). Journal Ec. Ent. Vol. 2, p. 356.

1910. *Schizoneura americana,* Patch, Edith M. (in part). Gall Aphids of the Elm. Me. Agr. Exp. Sta. Bul. 181, pp. 223-235.

1910. *Schizoneura americana,* Williams, T. A. (in part). The Aphididæ of Nebraska, p. 16.

1913. *Schizoneura americana,* Gillette. 25th Ann. Rept. of the Col. Agr. Exp. Sta. p. 30. "the leaf-rolling form" distinguished from "the form producing the rosette like cluster of leaves at the tip of elm twigs."

1913. *Schizoneura* sp. Patch. Ann. Ent. Soc. Am. Figs. 1 to 7.

1913. *Schizoneura americana* in part, of authors. Patch. Bul. 217. Me. Agr. Exp. Sta. p. 184. Habitat Key for Woolly Aphids of the Elm.

ELM-CURRANT APHID OF EUROPE.

Schizoneura ulmi (fodiens).

There is apparently little doubt that the literature for *ulmi* in Europe is as mixed as that for *americana* in this country, both being what is known as composite species. What *ulmi* of Linn. was is perhaps past finding out but however that may be that species which migrates to *Ribes* where it was known as *fodiens* evidently has as good a right to the name as any, and most of the recognizable figures are those of the *Ulmus-Ribes* species. That the life cycle of this leaf roller of elms (*Ulmus scabra, U. campestris, U. racemosa* and perhaps others) includes a residence on the roots of currants or gooseberries has been definitely established for Europe. Although the life cycle has not yet been followed through in America, specimens which I have seen collected from California, Oregon, Maine (1913), and Ontario (fall migrants, 1913) are, I believe, identical with *ulmi* (*fodiens*) of other countries and will doubtless prove to have the same cycle here. As will be seen from figure 138A and B the roll caused by *ulmi* is of the same type as that caused by *americana*, and as both species extend from Maine to California it is not unlikely that they have been confused in our literature. So far as I know at present *S. ulmi* from *Ulmus americana* is not recorded nor *S. americana* on the species of elm accepted by *S. ulmi*, but this whole question needs further study.

The first collection of this species made in Maine was at Bath June 23, 1913, when a box of the leaves containing stem mothers, pupæ and migrants were received with the statement that more than a bushel of such leaves had been taken from a Camperdown elm (*Ulmus scabra* Mill. var. *pendula*). Another collection from the same place was secured July 8.

On August 31, 1913, while in Bar Harbor I collected curled leaves from an English elm (*Ulmus campestris*) which contained molted pupal skins, the antennal structure of which proved the work to be that of *ulmi*. No live specimens were present, of course, at that date. The infested elm, though a good sized tree, had hardly a normal leaf. However much alike their rolls look the insects inside are readily distinguished in all their stages.

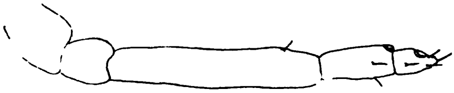

Fig. 136. The antenna of the stem mother. It is at once distinguished from that of the corresponding form of the other species treated in this paper by the very much abbreviated terminal joint.

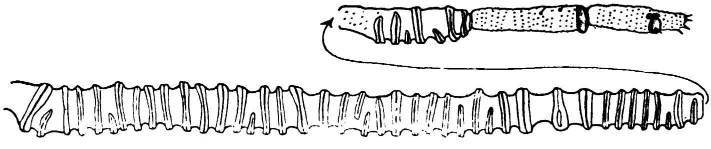

Fig. 137. The antenna of the spring migrant is strikingly different from any other elm species known to me. The annu-

lar sensoria are broad, the hollows between them deep, and they occur only on III+IV. III is nearly twice IV+V+VI in length. The terminal sensorium of V is more or less circular and fringed. In this respect it resembles the corresponding sensorium on the apterous forms of our other elm species whose winged forms have, however, lost this character, their terminal sensorium of V being apparently only a modified annulation a little broadened or otherwise irregular in shape.

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1857. *Schizoneura ulmi*, Koch. Pflanzenlause. Fig. 337, 338.

1879. *Schizoneura ulmi*, Courchet.

1880. *Schizoneura ulmi*. Kessler. Neue Beobachtungen und Entdeckungen an den auf *Ulmus campestris* L. vorkommenden Aphiden-Arten. Taf. II, Fig. 17-21.

1881. *Schizoneura ulmi*. Buckton Monogr. of Brit. Aphides. Vol. III. Pl. CVIII and CIX. Fig. 1-4.

1881. *Schizoneura fodiens*, Buckton. Monogr. of Brit. Aphides. Vol. III. Pl. CVI. Fig. 6-12.

1896. *Schizoneura fodiens*, Cholodkovsky. Aphidologische Mitteilungen. Zoöl. Anz. N. 520, p. 508-513.

1906. *Schizoneura ulmi* (*fodiens*), Schouteden. Cat. des Aphides de Belgique.

1909. *Schizoneura ulmi* (*fodiens*), Tullgren. Aphidologische Studien I. pp. 163-169 and Figs. 78-82.

1912. *Schizoneura ulmi* (*fodiens*), Theobald. Journ. Econ. Biol. Vol. VII, No. 3, pp. 111-115. Figs. 13 B and C and 14. (Fig. 13 A is evidently not *ulmi-fodiens*).

1913. *Schizoneura ulmi* (*fodiens*). Reh, L. Handbuch der Pflanzenkrankheiten von Prof. Dr. Paul Sorauer, Dritter Band. Die tierischen Feinde. Bearbeitet von Dr. L. Reh.

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1879. *Schizoneura ulmi*, Courchet. Etude sur les galles produites par les aphidiens, Mem. de. l'acad. Montpellier. p. 99. From description of antenna, evidently not *ulmi* (*fodiens*).

1908. *Schizoneura ulmi*, Okajima. Contribution to the Study of Japanese Aphididæ. Reprint Bul. Col. Agr. Tokyo Imperial Univ. Vol. VIII, No. 1. Plate II, Fig. 2. This is not *ulmi* (*fodiens*). III is shorter than IV+V+VI. V is at least twice IV in length and annulated. This antenna has much the same proportions and characters as Theobald 1912, Fig. 13 A and may possibly be the same species.

FOOD PLANT CATALOGUE OF THE APHIDAE OF THE WORLD.

PART III.*

EDITH M. PATCH.

MYRICACEAE. SWEET GALE FAMILY.

MYRICA.

M. Gale L. Sweet Gale.
Aphis myricae Kalt. Kaltenbach, 1874, p. 622.

JUGLANDACEAE. WALNUT FAMILY.

CARYA. (Hicoria) Hickory.

C. alba (L.) Koch. Mocker Nut, White-heart Hickory.
Monellia maculella (Fitch) (?). Gillette, 1910, p. 368.
Monellia marginella (Fitch). Gillette, 1910, p. 368.
Myzocallis (?) *caryaefoliae* (Davis). Gillette, 1910, p. 369.
Phylloxera caryae Fitch. Hunter, 1901, p. 70.
Phylloxera caryaeavellana Riley. Hunter, 1901, p. 70.
Phylloxera caryaefallax Walsh. Thomas, 1879, p. 164.
Phylloxera caryaefallax Riley. Williams, 1891, p. 15.
Phylloxera caryaefoliae Fitch. Hunter, 1901, p. 71.
Phylloxera caryaeglobuli Walsh (D. hemisphericum Shimer) Hunter, 1901, p. 71.
Phylloxera caryaegummosa Riley. Hunter, 1901, p. 71.
Phylloxera caryaescissa Riley. Hunter, 1901, p. 71.
Phylloxera caryaesepta (Shimer). Hunter, 1901, p. 71.
Phylloxera (*Pemphigus*) *caryaevenae* Fitch. Hunter, 1901, p. 71.
Phylloxera (D.) *conica* Shimer. Hunter, 1901, p. 71.
Phylloxera depressa (Shimer). Williams, 1891, p. 15.

C. cordiformis (Wang) K. Koch (amara Nutt) (minima) Bitter Nut or Swamp Hickory.
Lachnus longistigma Monell. Sanborn, 1904, p. 31.
Monellia caryella (Fitch) Oestlund (A. punctatella Fitch) (A. maculella Fitch) (A. fumipennella Fitch) (A. marginella Fitch). Oestlund, 1887, p. 45.
Phylloxera caryaecaulis Fitch. var magna Shimer. Pergande, 1904b, p. 246.

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* Papers from the Maine Agricultural Experiment Station: Entomology No. 69. For Parts I and II see Bulletins 202 and 213.

Phylloxera caryaecaulis Fitch (D. caryaemagnum Shimer). Hunter, 1901, p. 70.

Phylloxera conica Shimer. Pergande, 1904b, p. 226.

Phylloxera (*Dactylosphaera*) *foveata* Shimer ("forcatum" and "foreatum" by misprint). Pergande, 1904b, p. 209.

Phylloxera globosa Shimer. Pergande, 1904b, p. 238.

Phylloxera globosa var. coniferum (Shimer). Pergande, 1904b, p. 238.

Phylloxera (D.) *spinosa* Shimer. Hunter, 1901, p. 72.

C. glabra Will (Hicoria glabra) Pignut or Broom Hickory.

Aphis caryae Harris. Harris, 1841, also Flint ed. 1862, p. 238.

Phylloxera caryaecaulis (Fitch). Pergande, 1904b, p. 244.

Phylloxera caryaecaulis Fitch (Dactylosphoera subellipticum Shimer) (D. caryaemagnum Shimer). Hunter, 1901, p. 70.

Phylloxera caryaefoliae Fitch. Pergande, 1904b, p. 195.

Phylloxera caryaeglobuli Walsh (D. hemisphericum Shimer). Hunter, 1901, p. 71.

Phylloxera caryae-ren Riley. Pergande, 1904b, p. 257.

Phylloxera caryaesemen Walsh (D. globosum Shimer). Hunter, 1901, p. 71.

Phylloxera caryae-semen (Walsh). Pergande, 1904b, p. 213.

Phylloxera (*Dactylosphoera*) *caryae-septum* (Shimer). Pergande, 1904b, p. 194.

Phylloxera c-septum, var. perforans Pergande. Pergande, 1904b, p. 194.

Phylloxera foveola Pergande. Pergande, 1904b, p. 200.

Phylloxera (*D.*) *gibbosa* Shimer. Hunter, 1901, p. 72.

Phylloxera pilosula Pergande. Pergande, 1904b, p. 203.

C. illinoensis K. Koch. (Hicoria olivaeformis). Pecan.

Callipterus caryae Monell. Monell, 1879, p. 31.

Phylloxera devastatrix Pergande. Pergande, 1904b, p. 248.

Phylloxera notabilis Pergande. Pergande, 1904b, p. 235.

Phylloxera sp. Hunter, 1901, p. 75.

C. ovata (Mill) K. Koch. (Hicoria alba Nutt). Shell-bark or Shagbark Hickory.

Phylloxera caryae-fallax Riley. Pergande, 1904b, p. 214.

Phylloxera caryae-globuli Walsh (hemisphericum Shimer). Pergande, 1904b, p. 223.

Phylloxera caryae-gummosa Riley. Pergande, 1904b, p. 239.

Phylloxera caryae-scissa Riley. Pergande, 1904b, p. 220.

Phylloxera (*Dactylosphoera*) *caryae-septum* (Shimer). Pergande, 1904b, p. 194.

Phylloxera depressa (Shimer). Pergande, 1904b, p. 208.

Phylloxera intermedia Pergande. Pergande, 1904b, p. 199.

C. porcina Nutt.

Lachnus caryae (Harris). Hunter, 1901, p. 85.

C. tomentosa Nutt. (Hicoria tomentosa).

Phylloxera caryae-avellana Riley. Pergande, 1904b, p. 228.

Phylloxera caryae-caulis Fitch var. spinosa Shimer. Pergande, 1904b, p. 244.
Phylloxera caryae-scissa Riley. Pergande, 1904b, p. 220.
Phylloxera (*Pemphigus?*) *caryaevenae* Fitch. Pergande, 1904b, p. 240.
Phylloxera deplanata Pergande. Pergande, 1904b, p. 205.
Phylloxera perniciosa Pergande. Pergande, 1904b, p. 251.
Phylloxera picta Pergande. Pergande, 1904b, p. 198
Phylloxera rimosalis Pergande. Pergande, 1904b, p. 217.
Phylloxera symmetrica Pergande. Pergande, 1904b, p. 230.
Phylloxera symmetrica var. purpurea Pergande. Pergande, 1904b, p. 233.
Phylloxera symmetrica var. vasculosa Pergande. Pergande, 1904b, p. 233.

C. sp.

Callipterus caryae Monell. Monell, 1879, p. 31.
Callipterus caryaefoliae Davis. Davis, 1910a, p. 198.
Longistigma (*Lachnus*) *caryae* (Harris) Wilson. Wilson, 1909c, p. 385.
Phylloxera caryae-globosa Shimer. Thomas, 1879, p. 163.
Phylloxera (D.) *depressa* Shimer (D. coniferum Shimer). Hunter, 1901, p. 72.
Phylloxera georgiana Pergande. Pergande, 1904b, p. 249.
Phylloxera minimum (Shimer). Pergande, 1904b, p. 210.
Phylloxera spinuloides Pergande. Pergande, 1904b, p. 248.
Phylloxera subelliptica (Shimer). Pergande, 1904b, p. 250.
Schizoneura caryae (Fitch). Thomas, 1879, p. 141.

JUGLANS. Walnut.

T. californica Wats.

Monellia californica Essig. Essig, 1912, Aphid. So. Cal. X. p. 770.

J. nigra L. **Black Walnut.**

Lachnus longistigma Monell. Sanborn, 1904, p. 31.
Monellia caryae (Monell). Gillette, 1910, p. 367.
Monellia maculella (Fitch) (?). Gillette, 1910, p. 368.
Schizoneura caryae (Fitch). Williams, 1891, p. 26.

J. regia L. **English Walnut.**

Callipterus caryae Monell. Davidson, 1909, p. 301, "on English Walnut."
Callipterus juglandicola Koch. Essig, 1909, p. 52.
Callipterus juglandis (Frisch). Ferrari, 1872, p. 81.
Chromaphis juglandicola (Kalt.). Gillette, 1910, p. 367.
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Pterocallis juglandicola (Kalt.) (Lachnus Kalt.) (Aphis Walker) (Callipterus Koch). Buckton, 3, p. 34.
Ptychodes juglandis (Frisch) (Aphis) (Lachnus) (Callipterus) Buckton, 3, p. 41.

J. sp.

Aphis juglandina Walker. Walker, 1848a, p. 335.

BETULACEAE. BIRCH FAMILY.

ALNUS. Alder.

A. glutinosa (L.)

Aphis alni Fab. (nicht A. alni Schrank) (A. maculata Heyden). Kaltenbach, 1843, p. 138.
Callipterus giganteus Chol. Cholodkovsky, 1899, p. 474.
Pterocallis alni (Fab.), Pass. Buckton, 3, p. 32.

A. incana (L.) Willd. Speckled or Hoary Alder.

Callipterus giganteus Chol. Cholodkovsky, 1899, p. 474.
Pemphigus tessellata Fitch (acerifolii Riley). Patch, 1908, p. 484.
Vacuna alni (Schrank) Pass. (V. betulae Kalt.) (Glyphina betulae Koch). Passerini, 1863, p. 84.

A. rhombifolia Nutt.

Euceraphis flava Davidson. Davidson, 1912, p. 406.
Myzocallis alni (Fab). Essig, 1912, Aphid. So. Cal. X, p. 767.

A. rubra Boug.

Lachnus alnifoliae Fitch. Williams, 1891, p. 5.
Pemphigus tessellata Fitch (Chermes alni Kalm). Hunter, 1901, p. 79.

A. sp.

Aphis alni Fab. Kaltenbach, 1874, p. 620.
Aphis alni Schrank. Kaltenbach, 1874, p. 620.
Aphis bifrons Walker. Walker, 1848a, p. 444. "On alder?"
Callipterus (Pterocallis) alni Fab. Davis, 1910b, p. 415.
Glyphina alni Schrank. Lichtenstein, La Flore.
Lachnus alnifoliae Fitch. Thomas, 1879, p. 118. Essig, 1912, Aphid. So. Cal. X, p. 773.
Pemphigus alni Provancher. Kirkaldy, 1906, p. 15.
Pterocallis maculata Heyden. Lichtenstein, La Flore.

BETULA. Birch.

B. alba L. (papyracea Ait) (pubescens Ehrh) (papyrifera Marsh). Paper, Canoe or White Birch.

Aphis antennata Kalt. Kaltenbach, 1843, p. 115.
Aphis betularia Kalt. (A. tuberculata Heyden). Kaltenbach, 1843, p. 120.
Aphis comes Walker. Walker, 1848a, p. 258.
Aphis nigritarsis Heyden. Kaltenbach, 1843, p. 135.
Aphis quadrituberculata Kalt. Kaltenbach, 1843, p. 134.
Callipterus betulicola (Kalt.?) (C. betulae Koch). Buckton, 3, p. 16.
Callipterus betulaecolens (Fitch) Monell. Davis, 1909a, p. 30.
Callipterus oblongus Heyden (Aphis oblonga Heyden) Del Guercio, 1900, p. 111.
Chaitophorus betulae Buckton (?). Gillette, 1910, p. 367.

Chaitophorus betulinus van der Goot. Van der Goot. 1912, p. 278.
Glyphina alni Schrank (betulae Kaltenbach) (betulina Buckton). Schouteden, 1906a, p. 192.
Hamamelistes spinosus Shimer (Hormaphis papyraceae Oestlund) Oestlund, 1887, p. 20.
Symdobius oblongus (Heyden). Patch, 1910b, p. 245.
Symdobius oblongus Heyden. Schouteden, 1906a, p. 210.
Vacuna betulae Kalt. Kaltenbach, 1843, p. 177.

B. alpestris Fries.

Hamamelistes betulae Mordw. Tullgren, 1909, p. 58.

B. fontinalis.

Calaphis betulaecolens (Fitch). Gillette, 1910, p. 371.
Euceraphis betulae (Koch). Gillette, 1910, p. 371.
Hamamelistes spinosus Shimer. Gillette, 1909a, p. 353.

B. nigra L. River or Red Birch.

Calaphis betulella Walsh. Walsh, 1862, p. 302.
Hormaphis (*Brysocrypta*) *hamamelidis* Fitch (Hamamelistes cornu Shimer). Pergande, 1901, p. 8.

B. tremula.

Callipterus carpini Koch. (A. coryli Kalt?). Buckton, 3, p. 19.

B. sp.

Aphis antennata Kalt. Kaltenbach, 1874, p. 610.
Aphis betulae Linn. Kaltenbach, 1874, p. 609. Tullgren, 1909, p. 4.
Aphis (*Callipterus*) *betulae* Koch. Kaltenbach, 1874, p. 610.
Aphis betulicola Kalt. Kaltenbach, 1874, p. 609.
Aphis betulina Walker. Walker, 1852, p. 1039. Host plant not given.
Aphis callipterus Hartig. Hartig, 1841, p. 369.
Aphis comes Walker. Kaltenbach, 1874, p. 610.
Aphis impingens Walker. Kaltenbach, 1874, p. 610.
Aphis inhaerens Walker. Walker, 1852, p. 1041.
Aphis nigritarsis Heyden. Kaltenbach, 1874, p. 609.
Aphis quadrituberculata Kalt. Kaltenbach, 1874, p. 609.
Bradyaphis antennata ———. Mordwilko 1899, p. 407.
Callipteroides betulae (nigritarsis). Mordwilko, 1899, p. 407.
Callipterus betularius Kalt. (A. tuberculata Heyden?) (A. antennata Kalt?) (betulae Walker). Buckton, 3, p. 14.
Callipterus tuberculata Heyden. Lichtenstein, La Flore.
Chaitophorus annulatus Koch. Koch, p. 8.
Chaitophorus betulae Buckton. Buckton, 2, p. 140.
Chaitophorus tricolor Koch. Koch, p. 10 (A. betularia?).
?*Eriosoma imbricator* Fitch. "An insect closely allied to E. imbricator abundant on birch in Maryland in October." Glover, 1877, p. 39.
Eriosoma tessellata Fitch. Glover, 1877, p. 39.
Glyphina betulae Kalt. Tullgren, 1909, p. 48.
Glyphina betulae Heyden (Vacuna alni Pass.?) (Tremulinax Amyot). Buckton, 4, p. 18.

Hamamelistes betulae Mordwilko. (Mss. correction of Cerataphis betulae Mordwilko). Mordwilko, 1899, p. 973.

Hamamelistes (*Tetraphis*) *betulina* Horvath. Kirkaldy, 1906, p. 17.

Hamamelistes spinosus Shimer (Hormaphis papyraceae Oestlund). Pergande, 1901, p. 25.

Symdobius oblongus (Heyden). Mordwilko, 1899, p. 409.

Symdobius oblongus Heyden. Schouteden, 1906a, p. 210.

Vacuna betulae Kalt. Kaltenbach, 1874, p. 610.

CARPINUS. Hornbeam.

C. Betulus L.

Callipterus carpini Koch. (A. coryli Kalt?). Buckton, 3, p. 19.

Callipterus coryli (Goetze) Koch. Buckton, 3, p. 18.

Myzocallis coryli (Goetze) Pass. (A. avellanae Schrank) (C. coryli Koch) (C. carpini Koch). Passerini, 1863, p. 55.

CORYLUS. Hazelnut.

C. Avellana L.

Callipterus carpini Koch (A. coryli Kalt.). Koch, p. 216.

Callipterus coryli (Goetze) Koch. (Myzocallis coryli Pass.) Buckton, 3, p. 18.

Myzocallis coryli (Goetze) (Callipterus carpini Koch). Ferrari, 1872, p. 75.

Myzocallis coryli (Goetze) Pass. (A. avellanae Schrank) (C. coryli Koch) (C. carpini Koch). Passerini, 1863, p. 55.

Myzus tetrarhoda Walker (Aphis) (Siphonophora rosarum Koch) Ferrari, 1872, p. 61.

Siphonophora avellanae (Schr.) Koch (coryli Mosley) Buckton, 1, p. 150.

Siphonophora avellanae Koch. (A. avellanae Walker). Passerini, 1863, p. 12.

C. sp.

Callipterus (*Myzocallis*) *coryli* Goetze. Davis, 1910b, p. 417.

OSTRYA. Hop Hornbeam.

O. virginiana Mill. American Hop Hornbeam, Leverwood.

Siphonophora sp. ("apparently identical with S. geranii Oestlund"). Osborn and Sirrine, 1893, p. 236.

FAGACEAE. BEECH FAMILY.

CASTANEA. Chestnut.

C. dentata Marsh. Chestnut.

Calaphis castaneae (Fitch). Gillette, 1910, p. 368.

Callipterus castaneae Fitch. Thomas, 1879, p. 114.

C. pumila Mill. Chinquapin.
Callipterus quercus Kalt. Buckton, 3, p. 22.
C. sativa Mill. (Castanea vesca).
Aphis castanea-vesca Haldeman. Hunter, 1901, p. 95.
Callipterus castaneae Buckton. Buckton, 3, p. 26.
Dryaphis longipes (Dufour) (*Pterochlorus* Passerini) (*Lachnus* Buckton) (*Dryobius croaticus* Koch) Del Guercio, 1907 (1908). Redia V, pp. 277, 345.
Phylloxera (*Chermes*) *castaneae* Haldeman. Pergande, 1904b, p. 258.
Phylloxera sp. Hunter, 1901, p. 74.

FAGUS. Beech.

F. grandifolia Ehrh. (ferruginea) (Americana).
Pemphigus imbricator (Fitch). Weed, 1893, p. 302.
Pemphigus imbricator (Fitch). Jackson, 1908, p. 189.
Phyllaphis fagi Linn. Gillette, 1909a, p. 385.
Phyllaphis fagi (Linn)?. Weed, 1893, p. 302.
F. sylvatica L. (sylvestris).
Pemphigus fagi Koch. Passerini, Flora.
Phyllaphis fagi Linn. (Lachnus fagi Burmeister). Buckton, 3, p. 38.
Phyllaphis fagi Linn. Gillette, 1909a, p. 385.
Pterochlorus roboris Linn. (? fasciatus Burmeister). (exsicator Altum). Schouteden, 1906a, p. 208.
F. sp.
Aphis pallipes Hartig. Hartig, 1841, p. 369.
Chermes fagi Kalt. Hartig, R., 1880, p. 156, and Kaltenbach, 1874, p. 631.
Lachnus exsicator Altum. Hartig. R., 1880, p. 151.
Lachnus fagi Linn. Kaltenbach, 1874, p. 631.

QUERCUS. (Pasania) Oak.

Q. acuta Thunb.
Trichosiphum kuwanea Pergande. Okajima, 1908, p. 2.
Trichosiphum pasaniae Okajima. Okajima, 1908, p. 5.
Q. Aegilops L.
Vacuna dryophila (Schrank) Kalt. Passerini, 1863, p. 83.
Q. agrifolia Nee.
Schizoneura querci Fitch. Davidson, 1910, p. 374.
Q. alba L. White Oak.
Lachnus quercifoliae Fitch. Hunter, 1901, p. 85.
Myzocallis (?) sp. Gillette, 1910, p. 369.
Phylloxera querceti Perg. Pergande, 1904b, p. 265.
Phylloxera rileyi Riley (Licht. mss). Pergande, 1904b, p. 263.

Q. bicolor Willd. Swamp White Oak.

Callipterus discolor Monell (Myzocallis bella Thomas) (Myzocallis quercicola Thomas mss.) (C. asclepiadis Monell?). Hunter, 1901, p. 90.

Callipterus discolor Monell. Monell, 1879, p. 30.

Callipterus punctata Monell. Monell, 1879, p. 30.

Phylloxera rileyi Licht. Hunter, 1901, p. 72.

Q. cerris Linn.

Phylloxera spinulosa Targioni-Tozzetti. Zoölogical Record, 1875, p. 512.

Psylloptera quercina Ferrari. Ferrari, 1872, p. 86.

Pterochlorus longipes Leon Dufour (Aphis) (roboris Boyer) (Dryobius croaticus Koch). Ferrari, 1872, p. 82.

Dryaphis cerricola Del Guercio. Del Guercio, 1907 (1908) Redia V, p. 345.

Dryaphis roboris nigra Del Guercio. Del Guercio, 1907 (1908) Redia V, p. 345.

Q. coccifera L.

Phylloxera quercus Boyer, Buckton, 4, p. 50.

Q. coccinea Wang. Scarlet Oak.

Callipterus bellus (Walsh) (C. walshii Monell). Hunter, 1901, p. 89.

Q. cuspidata Thunb. (Pasania cuspidata Oerst.)

Trichosiphum pasaniae Okajima. Okajima, 1908, p. 5.

Trichosiphum tenuicorpus Okajima. Okajima, 1908, p. 4.

Q. dentata Thunb. (daimio.)

Phylloxera querceti Pergande. Pergande, 1904b, p. 265.

Q. Douglasii Hook and Arn.

Callipterus quercus Kalt (?). Davidson, 1910, p. 376.

Q. Farnetto Tenore (pannonica).

Phylloxera querceti Perg. Pergande, 1904b, p. 265.

Q. Ilex L. Evergreen Oak.

Aphis rumicis Linn. (fabae Kirby) (genistae Scop.) (ulicis Fab?) (Euphorbiae Kalt?) (dahliae Mosley) (Cinara rumicis Mosley) (Rumicifex Amyot) (Genistifex Amyot). Buckton, 2, p. 84.

Callipterus quercus (Kalt.) Koch. (Myzocallis quercus Pass.) Buckton, 3, p. 22.

Dryaphis ilicina Del Guercio. (*Aphis ilicicola* Boisduval) Del Guercio, 1907 (1908), Redia V, p. 345.

Dryaphis iliciphila Del Guercio. (*Aphis ilicicola* Boisduval) Del Guercio 1907 (1908) Redia V, p. 345.

Dryobius croaticus Koch (A. roboris Walker *not* Linn). Buckton, 3, p. 76.

Phylloxera coccinea Kalt. Passerini, Flora.

Phylloxera florentina Targioni. Buckton, 4, p. 71.

Phylloxera quercus Boyer. Fusclimi, 1906 (1907) Redia IV, p. 361.

Vacuna dryophila (Schrank) Kalt. Passerini, 1863, p. 83.

Q. imbricaria Michx. Laurel or Shingle Oak.
Callipterus hyalinus Monell. Monell, 1879, p. 30.

Q. Kelloggii Newberry. (Quercus californica.)
Callipterus quercus Kalt. (?). Davidson, 1910, p. 376. Davidson, 1909, p. 302.

Q. lamellosa Sm. (imbricata).
Callipterus hyalinus Monell. Clarke, 1903, p. 249.

Q. lobata Nee.
Callipterus quercus (?) Kalt. Davidson, 1909, p. 302.

Q. macrocarpa Mx. Bur Oak, Overcup or Mossy-cup Oak.
Callipterus bella (Walsh). Williams, 1891, p. 19.
Callipterus discolor Monell. Weed, 1888, p. 131.
Callipterus discolor Monell (Myzocallis bella Thos.). Oestlund, 1887, p. 41.
Callipterus punctata Monell. Williams, 1891, p. 7.
Chaitophorus spinosus Oestlund. Williams, 1891, p. 7.
Phylloxera querceti Perg. Pergande, 1904b, p. 265.
Schizoneura querci (Fitch). Williams, 1891, p. 7.

Q. mariiandica Muench. (marylandica). Black Jack or Barren Oak.
Lachnus longistigma Monell. Sanborn, 1904, p. 31.

Q. obtusiloba Michx.
Phylloxera rileyi Riley. Pergande, 1904b, p. 263.

Q. phellos L. Willow Oak.
Phyllaphis niger Ashmead. Hunter, 1901, p. 84.

Q. prinus L. Chestnut Oak.
Callipterus? quercicola Monell. Monell, 1879, p. 31.
Chaitophorus quercicola Monell. Monell, 1879, p. 32.

Q. pubescens.
Phylloxera coccinea Heyden. Lichtenstein, 1876, p. 11.
Phylloxera quercus Boyer. Buckton, 4, p. 50.

Q. Robur L. (pedunculata Ehrh) (fastigiata DC.) (sessiliflora).
Abamalekia lazarewi Del Guercio. Del Guercio, 1905 (1906) Redia III, p. 360.
Callipterus querceus (Kalt.) Koch. Buckton, 3, pp. 22, 26.
Dryaphis minor Del Guercio. Del Guercio, 1907 (1908) Redia V, p. 345.
Dryobius roboris (Linn.) Koch (Lachnus fasciatus Burm?) (Cinara roboris Curtis) (Lachnus roboris Kalt.) (Dryaphis Amyot). Buckton, 3, p. 73. Del Guercio, 1907 (1908) Redia V, p. 273
Lachnus longipes (Dufour) (A. roboris Boyer *not* Linn) (Pterochlorus longipes Rondani). Buckton, 3, p. 61.
Lachnus quercus (L.) Kalt. (A. fusca Geoffrey) (Phylloxera longirostris Boyer). Passerini, 1863, p. 65.
Lachnus roboris Linn. Kaltenbach, 1874, p. 677.
Myzocallis insignis Ferrari. Macchiati, 1883, p. 260.
Myzocallis quercus (Kalt.) Pass. Passerini, 1863, p. 54.

Phylloxera acantho-chermes Kollar (sub. Acantho-chermes quercus). Buckton, 4, p. 68.

Phylloxera coccinea Kalt. (Vacuna coccinea Heyden) (Ph. quercus Boyer). Passerini, 1863, p. 84.

Phylloxera coccinea Heyden. Buckton, 4, p. 68.

Phylloxera coccinea Heyd. (quercus Boyer). Kaltenbach, 1874, p. 677.

Phylloxera coccinea Heyden (quercus Balbiani nec Boyer). Schouteden, 1906a, p. 191.

Phylloxera corticalis Kalt. Buckton, 4, p. 68, and Kaltenbach, 1874, p. 677.

Phylloxera punctata Lichtenstein. Buckton, 4, pp. 68, 45.

Phylloxera punctata Licht. Lichtenstein, 1876, p. 12.

Phylloxera quercus Boyer (coccinea Passerini nec Heyden) (Balbianii Lichtenstein) (florentina Targioni-Tozzetti) (Lichtensteini Balbiani) (signoreti Targioni-Tozzetti). Schouteden, 1906a, p. 191.

Pterochlorus longipes (Dufour) Pass. (A. roboris Boyer) (Pt. roboris Rond.) (Dryobius croaticus Koch). Passerini, 1863, p. 67.

Pterochlorus longipes Dufour (nec Buckton!). (roboris Boyer) (croaticus Koch-Buckton) (? riparius Snellen van Vollenhoven). Schouteden, 1906a, p. 208.

Pterchlorus roboris Linne. (? fasciatus Burmeister) (exsiccator Altum). Schouteden, 1906a, p. 208.

Schizoneura lusitanica Horvath. Horvath, 1908, p. 132.

Stomaphis quercus (Linn) Del Guercio, 1907 (1908) Redia V, p. 344.

Thelaxes dryophila (Heyden) Westwood (Aphis dryophila Ratz). (Vacuda Amyot) (Cinara quercus O. Mosley) Buckton, 4, p. 10.

Vacuna dryophila Schrank (quercus Mosley) (quercicola Westwood) Schouteden, 1906a, p. 192.

Vacuna dryophila Schrank (Aphis). Ferrari, 1872, p. 85.

Q. rubra L. Red Oak.

Callipterus bellus (Walsh). Oestlund, 1887, p. 44.

Callipterus quercifolii Thomas. Thomas, 1879, p. 113.

Myzocallis bella (Walsh). Gillette, 1910, p. 368.

Myzocallis walshii (Monell). Gillette, 1910, p. 368.

Q. serrata Thunb.

Trichosiphum kuwanae Pergande. Pergande, 1906, p. 209.

Trichosiphum pasaniae Okajima. Okajima, 1908, p. 2.

Q. sessilifolia Blume.

Lachnus quercus (L.) Kalt. (A. fusca Geoffrey) (Phylloxera longirostris Boyer). Passerini, 1863, p. 65.

Phylloxera florentina Targ.-Toz. Lichtenstein, 1876, p. 12.

Q. suber.

Dryaphis minor Del Guercio. Del Guercio, 1907 (1908) Redia V, p. 345.

Tavaresiella suberi Del Guercio. Del Guercio, 1909 (1910) Redia VII, p. 297.

Q. virginiana Mill. (virens). Live Oak.

Lachnus quercicolens Ashmead. Hunter, 1901, p. 85.

Q. undulata Torr.

Schizoneura querci (Fitch). Hunter, 1901, p. 84.

Q. sp.

Acanthochermes quercus (Kollar) CB. Börner, 1909b, p. 60.
Aphis annulatus Hartig. Hartig, 1841, p. 369.
Aphis hirticornis Walker. Walker, 1848a, p. 447.
Aphis quercifoliae Walsh. Walsh, 1862, p. 298.
Aphis quercus-monticula Haldeman. Haldeman, 1844, p. 168.
Aphis suberis Tavares. Schouteden, 1906c.
Callipterus ? quercicola Monell. Monell, 1879, p. 31.
Chaitophorus quercicola Monell (Callipterus quercifolii Thomas) (Chait. spinosus Oestlund). Davis, 1910b, p. 415.
Chaitophorus spinosus Oestlund. Oestlund, 1887, p. 38.
Drepanosiphum? (Aphis) quercifoliae (Walsh). Thomas. Thomas, 1879, p. 79.
Dryobius longirostris Mordwilko. Mordwilko, 1909, p. 85.
Lachnus allegheniensis McCook. McCook, 1877, p. 274.
Lachnus (Dryobius) croaticus Koch. Kaltenbach, 1874, p. 677.
Lachnus fuscus Geoffrey. Lichtenstein, La Flore.
Lachnus longirostris Fab. Lichtenstein, La Flore.
Lachnus (Callipterus?) quercifoliae Fitch. Thomas, 1879, p. 118.
Longistigma (Lachnus) caryae (Harris). Wilson, 1909a, p. 385.
Moritziella (Phylloxera) corticalis (Kalt.) C. B. Börner, 1909b, p. 61.
Myzocallis bella (Walsh). Thomas, 1879, p. 106.
Myzocallis quercea (Kalt.) Pass. Passerini, 1863, p. 55.
Myzocallis quercus Kalt. (Aphis). Ferrari, 1872, p. 75.
Pemphigus pedunculi Hartig. Hartig, 1841, p. 367.
Phylloxera bipunctatum Licht. Lichtenstein, 1874, p. CCI.
Phylloxera coccinea Heyden. Börner, 1909b, p. 62.
Phylloxera-Foaiella (Börneria Grassi et Foa; nec. Willem, nec Axelson) danesii Grassi et Foa. Börner, 1909b, p. 61.
Phylloxera foae CB. Börner, 1909b, p. 62.
Phylloxera glabra Heyden. Börner, 1909b, p. 62.
Phylloxera scutifera Signoret. Lichtenstein, La Flore.
Phylloxera spinulosa Targioni. Lichtenstein, La Flore.
Phylloxera-Acanthaphis Del Guercio (Hystrichiella CB). spinulosa Tg.-Tz. Börner, 1909b, p. 62.
Schizoneura querci Fitch. Davis, 1910b, p. 413.
Schizoneura querci Fitch. Thomas, 1879, p. 139.
Stomaphis quercus Reaum. (Puceron de Chene Reaum) (A. quercus Linn) (longirostris Fab?) (Lachnus quercus Kalt.) Buckton, 3, p. 64.

Stomaphis macrorhyncha Chol. Cholodkovsky, 1894 (1895), p. 405. "auf eichenrinde."

Vacuna dryophila Schrank. Tullgren, 1909, p. 41.

URTICACEAE. NETTLE FAMILY.

ARTOCARPUS.

A. integrifolia L.

Greenidea (Siphonophora) artocarpi Westwood. Schouteden, 1905, p. 183.

CANNABIS. Hemp.

C. sativa L.

Aphis sativae Williams. Williams, 1910, p. 57.

Phorodon cannabis Pass. Ferrari, 1872, p. 60.

HUMULUS. Hop.

H. hepulus L. (neomexicanus).

Aphis gossypii Glover (citrifolii Ashmead, in part) (citrulli Ashmead) (cucumeris Forbes) (forbesi Weed?). Pergande, 1895, p. 314.

Aphis humuli Schrank. Kaltenbach, 1874, p. 534.

Myzus phenax Cockerell. Cockerell, 1903b, p. 115.

Phorodon humuli (Schrank) Pass. Passerini, 1863, p. 18.

Phorodon humuli (Schrank) Pass. (A. pruni Scop) (A. humulifex Amyot). Buckton, 1, p. 167.

MORUS. Mulberry.

M. sp.

Aphis mori Clarke. Clarke, 1903, p. 251.

PARIETARIA. Pellitory.

P. effusa.

- *Aphis urticaria* Kalt. Kaltenbach, 1874, p. 69.

P. officinalis L.

Aphis scabiosae Kalt. (A. chloris Koch?). Buckton, 2, p. 55.

Aphis urticae Fab. (urticaria Kalt.) Macchiati, 1883, p. 258.

P. sp.

Aphis parietariae Licht. (ined). Lichtenstein, La Flore.

PLANERA. Planer Tree.

P. sp.

Schizoneura lanuginosa Hart. Lichtenstein, Flore Supplement.

ULMUS. Elm.

U. americana L. American or White Elm.

Callipterus ulmifolii Williams. Williams 1891, p. 26, 1910, p. 2, "previously described by Monell."

Callipterus ulmifolii Monell (ulmicola Thos.). Oestlund, 1887, p. 42.

Callipterus sp. Sanborn. Sanborn, 1904, p. 42.

Callipterus n. sp. Sanborn. Sanborn, 1904, p. 41.

Colopha ulmicola (Fitch) Monell. Patch, 1910a, p. 197.

Pemphigus walshii Williams. Williams, 1910 (1911), p. 16.

Schizoneura americana Riley. Patch, 1913, Bul. 217 and Bul. 220.

Schizoneura lanigera (*americana* in part). Patch, 1913, Bul. 217, p. 173, Bul. 220, p. 264.

Schizoneura rileyi Licht. Williams, 1891, p. 26.

Schizoneura rileyi Thomas (Eriosoma ulmi Riley). Patch, 1910a, p. 235. 1913. Bul. 217, p. 184 and Bul. 220, p. 260.

Tetraneura graminis (colophoidea Monell) Monell. Patch, 1910a, p. 208.

U. campestris L. (suberosa) English Elm.

Callipterus elegans Koch (Lachnus platani Kalt.) Koch, p. 213.

Schizoneura lanuginosa Hartig. (A. ulmi Boyer) (Mimaphidus ulmi Rondani). Passerini, 1863, p. 70. Patch, 1913, Bul. 217, p. 184, Bul. 220, p. 263.

Schizoneura ulmi (Linn.) (fodiens Buckton). Tullgren, 1909, p. 169. Patch, 1913, Bul. 217, p. 184, Bul. p. 271.

Tetraneura (*Byrsocrypta*) *pallida* (Hal.) Del Guercio (A. alba Ratz) (T. alba Kessler) (P. pallidus Buckton). Tullgren, 1909, p. 185.

Tetraneura ulmi DeGeer (coerulescens Mordwilko nec Passerini) Schouteden, 1906a, p. 200.

Tetraneura ulmi Geoffr. (? Pemphigus coerulescens Pass.) Tullgren, 1909, p. 180.

U. fulva Michx (pubescens Walt.) Slippery or Red Elm.

Pemphigus ulmifusus Walsh. Patch, 1910a, p. 220.

U. montana With. Scabra Mill. (Camperdown pendula). Scotch or Wych Elm.

Schizoneura ulmi Linn. Connold, 1902, p. 245. Patch, 1913, Bul. 217, p. 184, Bul. 220, p. 271.

Tetraneura ulmi (Linn.). Patch, 1910a, p. 219.

Tetraneura ulmisacculi Patch. Patch, 1910a, p. 216.

U. racemosa Thomas. Cork or Rock Elm.

Colopha ulmicola (Fitch) Monell (eragrostidis Middleton). Patch, 1910a, p. 204.

U. sp.

Georgia ulmi Wilson. Wilson, 1911, p. 65.

Lachnus platani Kalt. Kaltenbach, 1874, p. 540.

Lachnus ulmi (Linn.) Thomas, 1879, p. 119 "error for Schizoneura ulmi (Linn.)."
Myzocallis ulmifolii (Monell). Gillette, 1910, p. 369.
Pemphigus pallidus (Haliday) (P. albus Licht.) (ulmi Licht?) Buckton, 3, p. 127.
Pemphigus ulmi Licht. Lichtenstein, 1880, pp. 1-5.
Schizoneura compressa Koch. Lichtenstein, La Flore.
Tetraneura alba Ratz? (Schizoneura compressus Koch) Kaltenbach, 1874, p. 540.
Tetraneura rubra Licht. Lichtenstein, La Flore.

URTICA. Nettle.

U. dioica Pursh. **Stinging Nettle.**
Aphis tertia Walker. Walker, 1849c, p. 45.
Aphis urticae Fab. (urticaria Kalt.). Ferrari, 1872, p. 65.
Aphis urticaria Kalt. Buckton, 2, p. 51.
Siphonophora pisi (Kalt.) Koch (A. ulmariae Schrank) (onobrychis Boyer) (lathyri Walker). Buckton, 1, p. 135.
Siphonophora urticae (Kalt, Schrank) Koch. Buckton, 1, p. 144.
U. gracilis Ait.
Siphonophora pisi Kalt. Williams, 1891, p. 18.
U. holosericea Nutt.
Macrosiphum pisi Kalt. Davidson, 1909, p. 304.
U. urens L.
Aphis rumicis Linn. Walker, 1850a, p. 19.
Aphis urticae Fab. (urticaria Kalt.). Macchiati, 1883, p. 258.
Aphis urticaria Kalt. Buckton, 2, p. 51.
Siphonophora carnosa Buckton. Buckton, 1, p. 145.
Siphonophora urticae (Kalt., Schrank) Koch. Buckton, 1, p. 145.
U. sp.
Aphis lamii Koch. Koch, p. 85.

POLYGONACEAE. BUCKWHEAT FAMILY.

ERIOGONUM.

E. alatum Torr.
Aphis eriogoni Cowen. Cowen, 1895, p. 119.
E. umbellatum Torr.
Aphis eriogoni Cowen. Cowen, 1895, p. 119.
E. sp.
Nectarophora martini Cockerell. Cockerell, 1903a, p. 171.

POLYGONUM. (Persicaria) Knotweed.

P. aviculare L.
Aphis ? polygoni Macchiati var. Schouteden, 1906a, p. 226.
Aphis polygoni Walker. Walker, 1848c, p. 2249.

Pemphigus betae Doane. Jackson, 1908, p. 218.
Phorodon galeopsidis Kaltenbach. Theobald, 1911-12.
Schizoneura corni (Fab.) (S. venusta Pass.) (E. fungicola Walsh) (E. cornicola Walsh) (S. panicola Thomas). Hunter, 1901, p. 81.
Sipha polygoni Schouteden. Schouteden, 1907, p. 265.

P. Hydropiper L. Common Smartweed or Water Pepper.
Phorodon galeopsidis Kalt. (Aphis). Ferrari, 1872, p. 60.

P. hydropiperoides Michx. Mild Water Pepper.
Aphis maidiradicis Forbes. Vickery, 1910, p. 103.

P. incarnatum Ell.
Aphis maidi-radicis Forbes. Davis, 1909b, p. 124.

P. lapathifolium L.
Aphis galeopsidis Kalt. Kaltenbach, 1874, p. 484.

P. laxiflorum.
Aphis galeopsidis Kalt. Kaltenbach, 1874, p. 484.

P. mite Schrank (dubium).
Phorodon galeopsidis (Kalt.) Pass. (Walker ex parte). Passerini, 1863, p. 19.

P. Muhlenbergii S. Wats.
Aphis maidiradicis Forbes. Vickery, 1910, p. 103.

P. pennsylvanicum L.
Aphis sp. Williams, 1891, p. 16.
Schizoneura corni (Fab.) Williams, 1910, p. 19.

P. persicaria L. Lady's Thumb.
Aphis dianthi Schrank. Walker, 1850a, p. 394.
Aphis maidi-radicis Forbes. Davis, 1909b, p. 124.
Aphis maidi-radicis Forbes. Vickery, 1910, p. 104.
Aphis maidis Fitch. Williams, 1891, p. 16.
Aphis rumicis Linn. (fabae Kirby) (genistae Scop.) (ulicis Fab?) (euphorbiae Kalt.?) (dahliae Mosley) (Cinara rumicis Mosley) (Rumicifex Amyot) (Genistifex Amyot). Buckton, 2, p. 84.
Aphis transiens Walker. Walker, 1849c, p. 44.
Phorodon galeopsidis (Kalt.) Pass. Buckton, 1, p. 173.
Schizoneura corni (Fab.) Williams, 1910, p. 19.
Siphonophora cerealis Koch (Aphis cerealis Kalt.) (A. avenae Walker *non* Schrank). Passerini, 1863, p. 11.
Siphonophora dirhoda Walker. Buckton, 1, p. 133.
Siphonophora granaria Kirby (avenae Fab?) (hordei Kyber) (cerealis Kalt.) (Bromaphis Amyot) Buckton, 1, p. 116.
Siphonophora polygoni Buckton. Buckton, 1, p. 123.
Siphonophora polygoni (Walker). Thomas, 1879, p. 62.

P. sp.
Amycla albicornis Koch. Koch, p. 305.
Aphis polygoni Licht. Lichtenstein, Flore Supplement.
Schizoneura panicola Thos. Hart, 1891 and 1892, p. 87.

RHEUM.

R. Rhaponticum L. **Rhubarb.**

Aphis rumicis Linn. (fabae Kirby) (genistae Scop.) (ulicis Fab?) (euphorbiae Kalt?) (dahliae Mosley) (Cinara rumicis Mosley) (Rumicifex Amyot) (Genistifex Amyot). Buckton, 2, p. 82.

Aphis rhei Koch? Theobald, 1911-12.

R. sp.

Aphis rhei Koch. Koch, p. 127.

RUMEX. Dock.

R. acetosa L. **Garden Sorrel.**

Aphis acetosae Buckton. (molluginis Koch?). Buckton, 2, p. 81.

Aphis rumicis Linn. Thomas, 1879, p. 88.

R. acutifolius.

Aphis rumicis Linn. Walker, 1850a, p. 18.

R. altissimus Wood. **Pale Dock.**

Aphis atriplicis Linn. Williams, 1891, p. 10.

Aphis maidi-radicis Forbes. Davis, 1909b, p. 124.

Aphis rumicis Linn. Williams, 1891, p. 10.

R. conglomeratus Murr.

Aphis acetosae Fab. Kaltenbach, 1874, p. 519.

Aphis rumicis Linn. Walker, 1850a, p. 18.

R. crispus L. **Yellow Dock.**

Aphis gossypii Glover (citrifolii Ashm. In part) (citrulli Ashm.) (cucumeris Forbes) (forbesi Weed?). Pergande, 1895, p. 313.

Aphis maidi-radicis Forbes. Davis, 1909b, p. 124.

Aphis rumicis Linn. Sanborn, 1904, p. 47.

Aphis rumicis Linn. (fabae Kirby) (genistae Scop.) (ulicis Fab?) (euphorbiae Kalt?) (dahliae Mosley) (Rumicifex Amyot) (Genistifex Amyot). Buckton, 2, p. 83.

Nectarophora tabaci Pergande. Pergande, 1898, p. 300.

R. obtusifolius L.

Aphis rumicis Linn. Walker, 1850a, p. 18.

R. occidentalis S. Wats.

Pemphigus betae Doane. Davidson, 1909, p. 299.

R. pulcher L.

Aphis rumicis Linn. Macchiati, 1883, p. 257.

R. venosus Pursh.

Aphis rumicis Linn. Williams, 1891, p. 10.

R. sp.

Aphis carbocolor Gillette. Gillette, 1907a, p. 391.

Aphis malvae Walker. Buckton, 2, p. 43.

Aphis ochropus Koch. Theobald, 1913, Journ. Bd. Agr. Vol. 19. Feb.

Aphis relata Walker. Walker, 1849c, p. 44.

Aphis rumicis? L. (euonymi Fab.). Hayhurst, 1909b, p. 98.

Myzus persicae Sulzer. Gillette and Taylor, 1908, p. 36.

CHENOPODIACEAE. GOOSEFOOT FAMILY.

ATRIPLEX. Orach.

A. babingtoni.
Aphis atriplicis Linn. Theobald, 1913. Journ. Bd. Agr. 19. Feb.

A. canescens James (Obione tetraptera).
Aphis tetrapteralis Cockerell. Cockerell, 1902.

A. hastata L. (latifolia.)
Aphis atriplicis Linn. (A. chenopodii Schrank) (A. atriplicis Pass.?). Buckton, 2, p. 88.
Aphis papaveris Fb. Kaltenbach, 1874, p. 269.
Aphis rumicis Linn. Walker, 1850a, p. 19.

A. hortensis L.
Aphis rumicis Linn. (cracae Linn.) (fabae Scop.) (genistae Scop.) (acetosae Linn.) (euonymi Fab.) (papaveris Fab.) (hortensis Fab.) (viciae Fab.) (chenopodii Schrank) (thlaspeos Schrank) (armata Hausm.) (laburni Kalt.) (dahliae Mosley) (viburni Scop.). Hunter, 1901, 1, 104.

A. littoralis.
Aphis atriplicis Linn. Theobald, 1913. Journ. Bd. Agr. 19. Feb.

A. patula L. (angustifolia)
Aphis atomaria Walker. Walker, 1849c, p. 50.
Aphis atriplicis L. (Chenopodii Schrank). Passerini, 1863, p. 47.
Aphis atriplicis L. (Uraphis-Hayhurstia atriplicis Del G.) Hayhurst, 1909b, p. 88.
Aphis chenopodii Schrank (A. atriplicis Linn ist nicht A. atriplicis Fab.). Kaltenbach, 1843, p. 107.
Aphis papaveris Fab. Kaltenbach, 1874, p. 508.

A. portulacoides L.
Aphis atriplicis Linn. (not Buckton). Theobald, 1911-12.

BETA.

B. vulgaris L. (maritima) Cultivated Beet.
Aphis atriplicis L. (Uraphis-Hayhurstia atriplicis Del G.) Hayhurst, 1909b, p. 88. Theobald, 1911-12.
Aphis brevisiphona Theobald. Theobald, 1913. Journ. Bd. Agr. Vol. 19. Feb.
Aphis chaerophyllii Koch? Theobald, 1911-12.
Aphis cucumeris Forbes. Williams, 1891, p. 6.
Aphis dianthi Schrank. Walker, 1850a, p. 394.
Aphis papaveris Fab. Kaltenbach, 1874, p. 510.
Aphis rumicis Linn. Walker, 1850a, p. 19.
Myzus persicae Sulzer. Gillette and Taylor, 1908, p. 36.
Nectarophora erigeronensis Thomas. Hunter, 1901, p. 114

Pemphigus betae Doane. Jackson, 1908, p. 218.
Pemphigus betae Doane. (populicaulis Fitch?). Clarke, 1903, p. 248.
Siphonophora pisi (Licht.) Williams. Williams, 1891, p. 6.
Smynthurodes betae Westwood. Kirkaldy, 1906, p. 9.
Trifidaphis radicicola Essig. Essig, 1912a, p. 699.

CHENOPODIUM. Goosefoot.

C. album L. **Lamb's Quarters. Pigweed.**
Aphis atriplicis L. (Uraphis-Hayhurstia atriplicis Del Guercio) Hayhurst, 1909b, p. 88. Theobald, 1911-12.
Aphis atriplicis L. (chenopodii Schrank). Passerini, 1863, p. 47.
Aphis chenopodii Cowen. Cowen, 1895, p. 119.
Aphis gossypii Glover (citrifolii Ashmead. In part) (citrulli Ashmead) (cucumeris Forbes) (forbesi Weed?). Pergande, 1895, p. 313.
Aphis maidiradicis Forbes. Vickery, 1910, p. 101, 103.
Aphis papaveris Fab. Kaltenbach, 1874, p. 269.
Aphis rumicis? L. (euonymi Fab.). Hayhurst, 1909, p. 98.
Myzus persicae Sulzer. Gillette and Taylor, 1908, p. 36.
Pemphigus betae Doane. Gillette, 1909a, p. 354.
Pemphigus lactucarius Pass. (Amycla fuscicornis Koch). Buckton, 3, p. 125.

C. anthelminthicum L. **Wormseed.**
Aphis gossypii Glover (citrifolii Ashm. In part) (citrulli Ashm.) (cucumeris Forbes) (forbesi Weed?). Pergande, 1895, p. 313.

C. hybridum L. **Maple-leaved Goosefoot.**
Aphis atriplicis Linn. Williams, 1891, p. 20. Theobald, 1913. Journ. Bd. Agr. Vol. 19. Feb.
Aphis rumicis Linn. Williams, 1891, p. 20.

C. murale L.
Aphis atriplicis Linn. Davidson, 1912. p. 408.

C. polyspermum L.
Aphis atriplicis Linn. Davidson, 1912, p. 408.
Aphis atripticis Linn. (not Buckton). Theobald, 1911-12.

C. vulvaria L.
Aphis atriplicis Linn. Theobald, 1913.

C. urbicum.
Aphis atriplicis Linn. Theobald, 1913.

C. sp.
Aphis atriplicis Linn. (A. chenopodii Cowen). Gillette, 1910, p. 405.
Aphis chenopodii Schrank. Lichtenstein, La Flore.
Aphis (Amycla) fuscicornis Koch. Kaltenbach, 1874, p. 342.
Aphis ochropus Koch. Kaltenbach, 1874, p. 505.
Aphis rumicis Linn. Thomas, 1879, p. 88.

SALSOLA. Saltwort.

S. Kali L. (Tragus). Common Saltwort.
Aphis arundinis Walker. Buckton, 2, p. 112.
Aphis rufula Walker. Walker, 1849c, p. 47.
Myzus persicae Sulzer. Gillette and Taylor, 1908, p. 35.

SPINACIA.

S. oleracea Will. Spinach.
Aphis gossypii Glover (citrifolii Ashm. in part) (citrulli Ashm.) (cucumeris Forbes) (forbesi Weed?). Pergande, 1895, p. 314.
Aphis rumicis Linn. Walker, 1850a, p. 19.
S. sp.
Aphis brassicae Linn. Lichtenstein, Flore Supplement.
Aphis papaveris Fab. Lichtenstein, Flore Supplement.
Rhopalosiphum persicae Sulzer. Lichtenstein, Flore Supplement

AMARANTHACEAE. AMARANTH FAMILY.

ACHYRANTHES.

A. sp.
Myzus achyrantes (Monell) (M. malvae Oestlund). Oestlund, 1887, p. 74.
Myzus persicae Sulzer (Siphonophora achyrantes Mon.?). Gillette and Taylor, 1908, p. 34.

ALTERNANTHERA.

A. sp.
Myzus persicae Sulzer. Gillette and Taylor, 1908, p. 35.

AMARANTHUS. Amaranth.

A. graecizans L. (albus L.) Tumble Weed.
Aphis papaveris Fab. (thlaspeos Schrk.) (aparines) (fabae Scopoli) Ferrari, 1872, p. 71.
Aphis sp. Weed. Weed, 1888, p. 125.
A. hybridus L. Green Amaranth, Pigweed.
Aphis maidi-radicis Forbes. Davis, 1909b, p. 124.
A. retroflexus L. Green Amaranth, Pigweed.
Aphis gillettei Cowen. Cowen, 1895, p. 120.
Aphis maidi-radicis Forbes. Vickery, 1910, p. 102.
Tetraneura phaseoli (Pass.). Essig, 1909, p. 75.
Trifidaphis (*Pemphigus*) *radicicola* (Essig) Del Guercio. Essig 1909, p. 75.
Tychea phaseoli Pass. Passerini, 1860, p. 40.

A. spinosus L. Thorny Amaranth.
Aphis maidi-radicis Forbes. Vickery, 1910, p. 102.
A. sp.
Aphis gossypii Glover (citrifolii Ashm. In part) (citrulli Ashm.) cucumeris Forbes) (forbesi Weed?). Pergande, 1895, p. 313.
Myzus achyrantes (Monell). Williams, 1891, p. 5.
Myzus persicae Sulzer. Gillette and Taylor, 1908, p. 35.

Iresine.

I. Lindeni Van Houtte (Achyranthes).
Myzus persicae Sulzer. Gillette and Taylor, 1908, p. 35.

NYCTAGINACEAE. FOUR O'CLOCK FAMILY.

BOUGAINVILLAEA.

B. brasiliensis Willd.
Aphis papaveris Fab. var. Del Guercio, 1909 (1910) Redia VII, p. 297.

OXYBAPHUS. (Allionia)

O. linearis (Pursh) Robinson. (Allionia linearis) (angustifolius).
Aphis oxybaphi Oestlund. Oestlund, 1887, p. 62.
O. nyctagineus (Michx).
Aphis oxybaphi Oestlund. Williams, 1891, p. 20.

AIZOACEAE.

MESEMBRIANTHEMUM.

M. sp.
Rhopalosiphum dianthi (Schrank) Koch (persicae, Purceron du pecher Morren) (rapae Curtis) (floris rapae Curtis) (dubia? Curtis) (vastator Smee) (persicaecola Boisduval) (persicae Pass. *not* Boyer, *not* Sulzer, *not* Kalt.). Buckton, 2, p. 17.
Rhopalosiphum persicae Sulzer. Lichtenstein, La Flore.

CARYOPHYLLACEAE. PINK FAMILY.

Arenaria.

A. peploides L.
Aphis aucta Walker. Walker, 1849c, p. 33.

CERASTIUM. Mouse-ear Chickweed.

C. arvense L. Field Mouse-ear Chickweed.
Aphis cerastii Kalt. Kaltenbach, 1874, p. 58.
C. triviale Link.
Brachycolus stellariae Hardy. (holci Hardy). Buckton, 2, p. 148.

CUCUBALUS.

C. sp.
Aphis lychnidis Linn. Lichtenstein, Flore Supplement.

DIANTHUS. Pink.

D. Caryophyllus L.
Phorodon cynoglossi Williams. Williams, 1910, p. 88.
Rhopalosiphum dianthi (Schr.) Koch. (persicae, Puceron du pecher Morren) (rapae Curtis (floris rapae Curtis) (dubia? Curtis) (vastator Smee) (persicaecola Boisduval) (R. persicae Pass.) Buckton, 2, p. 17.
Rhopalosiphum persicae (Sulzer) Pass. (dianthi Schrank) (A. vulgaris Kyber) (A. rapae Curtis) (A. dubia Curtis) (A. vastator Smee). Passerini, 1863, p. 20 and Passerini, Flora.
D. plumarius L.
Aphis subterranea Walker. (A. carotae Koch).. Buckton, 2, p. 38.
D. prolifer. See Tunica prolifera Scop.

LYCHNIS. (Agrostemma) Campion.

L. dioica L. (diurna). Red Campion.
Aphis lychnidis Linn. Buckton, 2, p. 74.
Aphis plantaginis Schrank (A. dauci Fab.). Kaltenbach, 1843, p. 59.
Aphis plantaginis Fab. Kaltenbach, 1874, p. 56.
L. divaricata Reichb. (vespertina).
Aphis lychnidis Linn. Buckton, 2, p. 74.
L. Githago L. (Agrostemma Githago L.)
Siphonophora cichorii Koch. Buckton, 1, p. 164.
L. Viscaria Linn.
Aphis lychnidis Linn. Buckton, 2, p. 74.

SILENE. Catchfly.

S. italica Pers.
Myzus lychnidis Koch (Aphis). Ferrari, 1872, p. 61.
S. latifolia (Mill.) (inflata Sm.) (cucubalus Wibel). Bladder Campion.
Anuraphis lychnidis (Linn). Del Guercio, 1909 (1910) Redia VII, p. 297.

Aphis cucubali Pass. Kaltenbach, 1874, p. 772.
Aphis silenea Ferrari. Ferrari, 1872, p. 72.
Hyalopterus melanocephalus Buck. Buckton, 2, p. 117.
Myzus lychnidis Koch (Aphis). Ferrari, 1872, p. 61.
Pemphigus inflatae Del Guercio. Del Guercio, 1909 (1910) Redia VII, p. 298.

Spergula Spurry.

S. maritima With.
Aphis cardiva Walker. Walker, 1849c, p. 32.
S. arvensis Linn. Corn Spurry.
Aphis dianthi Schrank. Walker, 1850a, p. 394.

STELLARIA. (Alsine) Chickweed.

S. aquatica (L.) Scop. (Cerastium aquaticum).
Aphis nasturtii Kalt. Kaltenbach, 1874, p. 57.
S. graminea L.
Brachycolus stellariae (Hardy) Buckton (A. holci Hardy). Buckton, 2, p. 148.
Macrosiphum stellariae Schrank. Theobald, 1911-12.
S. holostea L.
Aphis pisi Kalt. Kaltenbach, 1874, p. 60.
Brachycolus stellariae (Hardy) Buckton (A. holci Hardy). Buckton, 2, p. 148.
S. (Alsine) media (L.) Cyrill. Common Chickweed.
Aphis gossypii Glover (citrifolii Ashm. In part) (citrulli Ashm.) (cucumeris Forbes) (forbesi Weed?) Pergande, 1895, p. 313.
Myzus persicae Sulzer. Gillette and Taylor, 1908, p. 35.
S. sp.
Aphis cerastii Kalt. Kaltenbach, 1874, p. 60.

TUNICA.

T. prolifera Scop. (Dianthus prolifer.)
Aphis dianthi Schrank. Walker, 1850a, p. 394.

PORTULACACEAE. PURSLANE FAMILY.

PORTULACA. Purslane.

P. oleracea L. Common Purslane.
Aphis gossypii Glover (citrifolii Ashm. in part) (citrulli Ashm.) (cucumeris Forbes) (forbesi Weed?). Pergande, 1895, p. 313.
?*Aphis gossypii* Glover. Fullaway, 1909, p. 39.
Aphis laburni Kaltenbach. Del Guercio, 1909 (1910) Redia VII, p. 297.

Aphis maidi-radicis Forbes. Davis, 1909b, p. 124.
Aphis portulacae Pass. (Ined.) . Lichtenstein, Flore Supplement. Del Guercio, 1909 (1910) Redia VII, p. 297.
Myzus portulacae Macchiati. Macchiati, 1883, p. 280.

NYMPHAEACEAE. WATER LILY FAMILY.

NELUMBO. Sacred Bean.

N. lutea Willd. Yellow Nelumbo, Water Chinquapin.
Aphis nymphaeae Linn. Kaltenbach, 1874, p. 20.

NUPHAR.

N. luteum. See Nelumbo lutea.

NYMPHAEA. Yellow Pond Lily.

N. alba L.
Rhopalosiphum nymphaeae (Linn.) Koch. Buckton, 2, p. 13.
N. lutea.
Rhopalosiphum nympharae (L.) Koch (A. butomi Schrank) (R. najadum Koch). Passerini, 1863, p. 21.
N. odorata Dry. (Castalia)
Rhopalosiphum nymphaeae Linn. (Aphis aquaticus Jackson). Davis, 1910a, p. 245.

RANUNCULACEAE. CROWFOOT FAMILY.

ACONITUM. Aconite. Monkshood.

A. Cammarum L.
Myzus junackianus Karsch. Karsch, 1887, p. XXI.
A. Napellus L.
Aphis napelli Schrank. Kaltenbach, 1874, p. 15.

AQUILEGIA. Columbine.

A. canadensis L. (Wild Columbine.
Aphis (*Adactynus*) *aquilegia-canadensis* Raf. Rafinesque, 1817.
A. vulgaris L. Garden Columbine.
Aphis dianthi Schrank. Walker, 1850a, p. 394.
Hyalopterus aquilegiae Koch. Koch, p. 19.
Hyalopterus aquilegiae-flavus (Kittel) (Aphis) (flavus Scheuteden) (aquilegiae Koch) (trirhoda Walker). Hayhurst, 1909a, p. 112.
Hyalopterus equilegiae Koch. Koch, p. 19.
Hyalopterus aquilegiae-flavus (Kittel) (Aphis) (flavus Schonteden) (aquilegiae Koch) (trirhoda Walker). Hayhurst, 1909a, p. 112.

Hyadaphis flavus Kittel. (aquilegiae Koch) (trirhodus Walker). Schouteden, 1906a, p. 230.

Hyalopterus trirhoda (Walker) Pass. (H. aquilegiae Koch). Buckton, 2, p. 115.

A. sp.

Aphis malvae Walker (A. malvae Pass. *not* S. malvae Pass.) Buckton, 2, p. 43.

CALTHA. Marsh Marigold.

C. palustris L.

Aphis calthae Koch. Koch, p. 48. Theobald, 1911-12.

CLEMATIS. Virgin's Bower.

C. Flammula L.

Aphis clematidis Ferrari. Del Guercio, 1900, p. 140.

C. ligusticifolia Nutt.

Myzus varians Davidson. Davidson, 1912, p. 411.

C. recta L. (erecta.)

Aphis clematidis Koch. Kaltenbach, 1874, p. 5.

C. Vitalba L.

Aphis clematidis Koch. Kaltenbach, 1874, p. 5.

Aphis urticae Fab. (urticaria Kalt.). Ferrari, 1872, p. 65.

Aphis vitalbae Ferrari. Lichtenstein, La Flore.

C. sp.

Toxoptera clematidis Del Guercio. Phillips and Davis, 1912, p. 8.

DELPHINIUM. Larkspur.

D. sapellonis.

Aphis rociadae Cockerell. Cockerell, 1903b, p. 115.

RANUNCULUS. Crowfoot.

R. acris L. Tall Crowfoot or Buttercup.

Aphis dianthi Schrank. Walker, 1850a, p. 394.

Aphis ranunculi Kalt. Kaltenbach, 1874, p. 10.

R. bulbosus L. Bulbous Crowfoot or Buttercup.

Pemphigus ranunculi Kalt. Kaltenbach, 1874, p. 10.

Rhopalosiphum dianthi (Schrank) Koch (persicae, Puceron du pecher, Morren) (rapae Curtis) (A. floris rapae Curtis) (dubia? Curtis) (vastator Smee) (persicaecola Boisduval) (Rh. persicae Pass.) Buckton, 2, p. 17.

Rhopalosiphum persicae (Sulzer) Pass. (A. dianthi Schrank) (A. vulgaris Kyber) (A. rapae Curtis) (A. dubia Curtis) (A. vastator Smee). Passerini, 1863, p. 20.

R. californicus Benth.

Pemphigus (*californicus* Davidson) (*ranunculi* Davidson). Davidson, 1910, p. 373 and 1911, p. 414. Essig, 1912a, p. 703.

R. Flammula L. Smaller Spearwort.

Thecabius (*Pemphigus*) *affinis* Kalt. (ranunculi Kalt.). Tullgren, 1909, p. 110.

R. muricatus L.

Aphis ranunculi Kalt. Macchiati, 1883, p. 257.

R. sardous Crantz (hirsutus).

Aphis dianthi Schrank, Walker, 1850a, p. 394.

R. repens L. Creeping Buttercup.

Aphis dianthi Schrank. Walker, 1850a, p. 394.

Aphis ranunculi Kalt. Kaltenbach, 1874, p. 10.

Thecabius (*Pemphigus*) *affinis* Kalt. (ranunculi Kalt.). Tullgren, 1909, pp. 110-111.

R. sceleratus L. Cursed Crowfoot.

Rhopalosiphum nymphaeae (L.) Koch. (A. butomi Schrank) (R. najadum Koch). Passerini, 1863, p. 21.

R. velutinus Ten.

Myzus ranunculi Del Guercio. Del Guercio, 1900, p. 151.

Pemphigus ranunculi Kalt. Passerini, Flora.

Trama ranunculi Del Guercio (*radicis* Kaltenbach?) (*flavescens* Koch?) Del Guercio, 1907 (1908) Redia V, pp. 248, 344.

R. sp.

Aphis ranunculina Walker. Walker, 1852, p. 1046.

THALICTRUM. Meadow Rue.

T. minus L.

Aphis dianthi Schrank. Walker, 1850a, p. 394.

Aphis thalictri Koch. Kach, p. 81.

T. polygamum Muhl. Tall Meadow Rue.

Myzus thalictri Williams. Williams, 1910, p. 69.

T. revolutum DC. (purpurascens L.)

Myzus thalictri Williams. Williams, 1891, p. 17.

Nectarophora purpurascens Oestlund. Oestlund, 1887, p. 81.

T. sp.

Aphis thalictri Koch. Kaltenbach, 1874, p. 6.

MAGNOLIACEAE. MAGNOLIA FAMILY.

LIRIODENDRON. Tulip Tree.

L. tulipifera L.

Macrosiphum liriodendri (Monell). Davis, 1909a, p. 36.

Macrosiphum liriodendri var. rufa (Monell). Davis, 1909a, p. 36.

MAGNOLIA.

M. grandiflora L.

Aphis magnoliae Macchiati. Macchiati, 1883, p. 254.

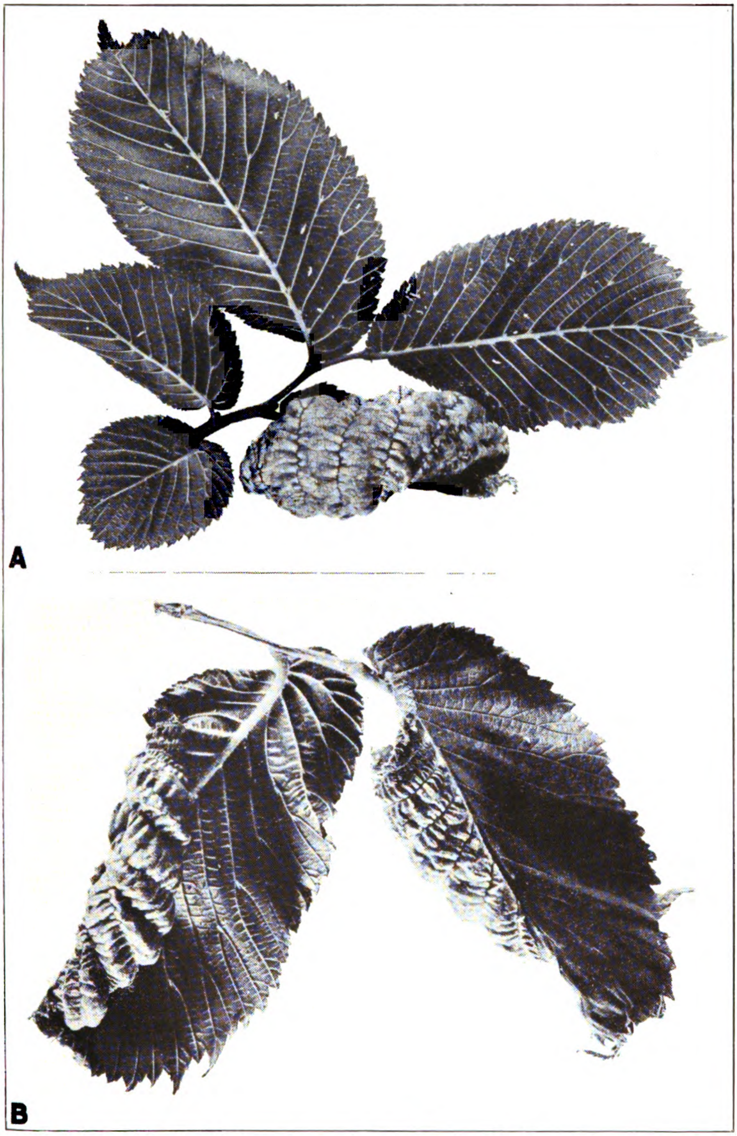

FIG. 138. A, work of *S. ulmi*, whole leaf involved. B, work of *S. ulmi*, half leaf involved. Left hand shows under surface of leaf, right hand shows upper surface. Maine specimens.

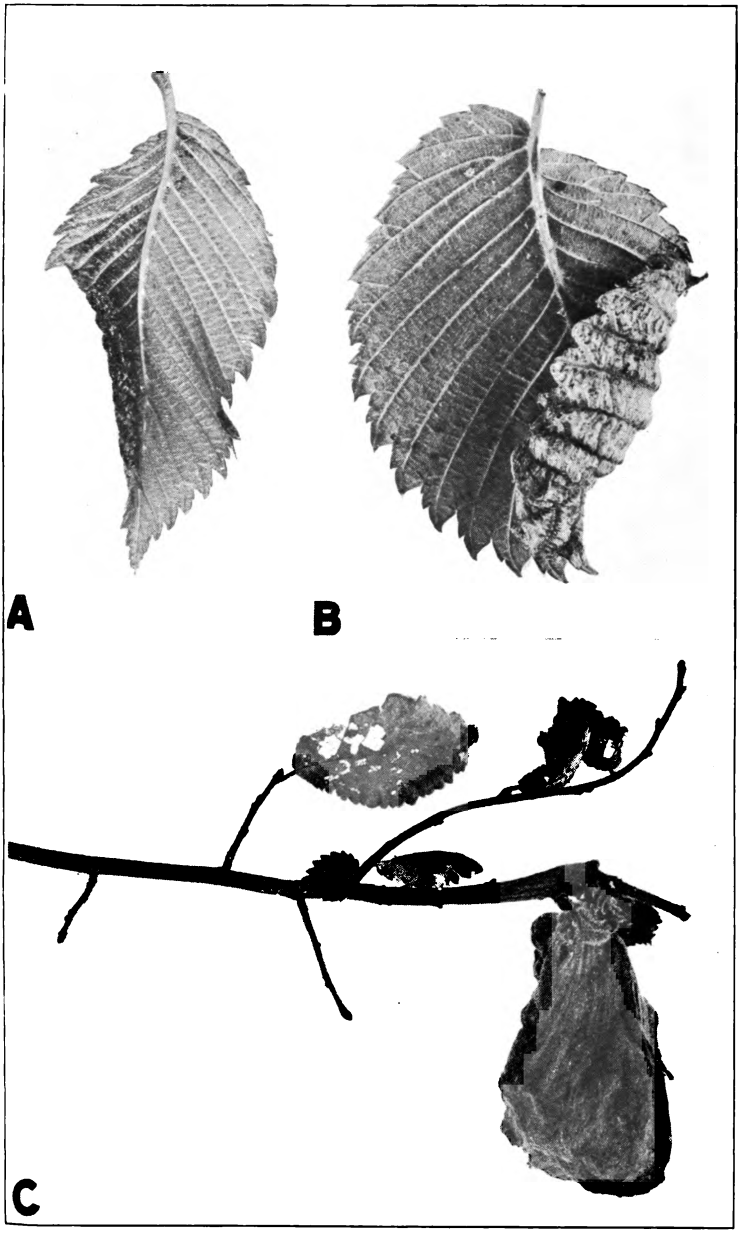

FIG. 139. A, work of *S. americana* in part of authors, young roll containing stem female. B, same species, old roll just deserted by migrants. Maine specimens. C, *S. lanuginosa*? Connecticut specimen.

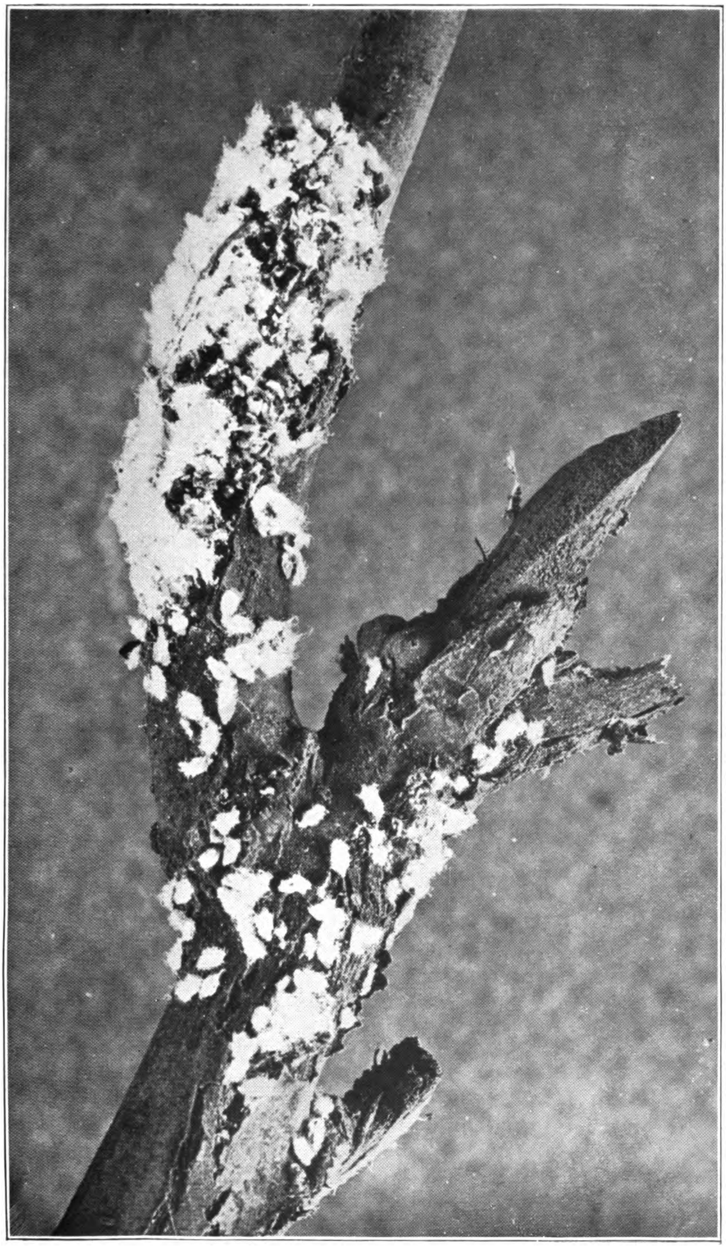

Fig. 140. *S. rileyi.*

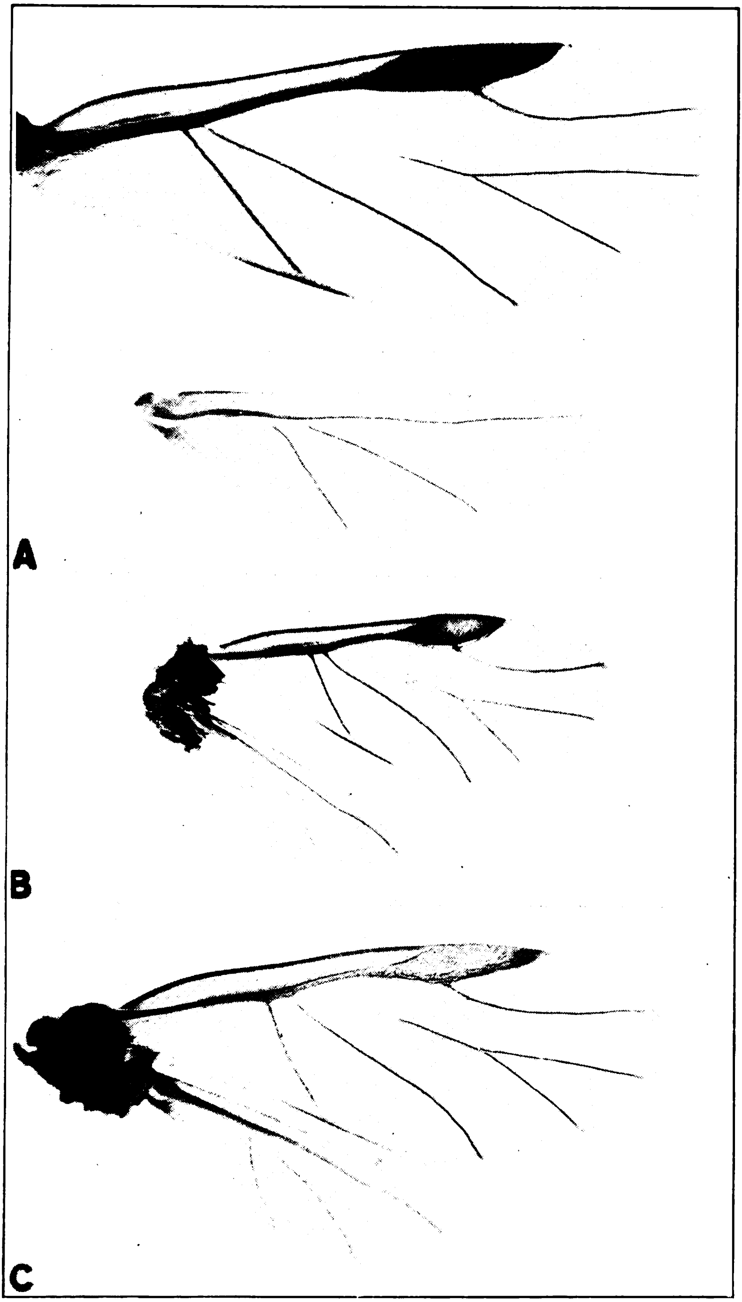

FIG. 141. A, *S. ulmi*, wings of spring migrant, (89–13). B, *S. lanigera*, wings of fall migrant (9-12 Sub. 1) reared on apple, the spring progenitors being migrants from elm leaves. C, *S. rileyi* (7–08).

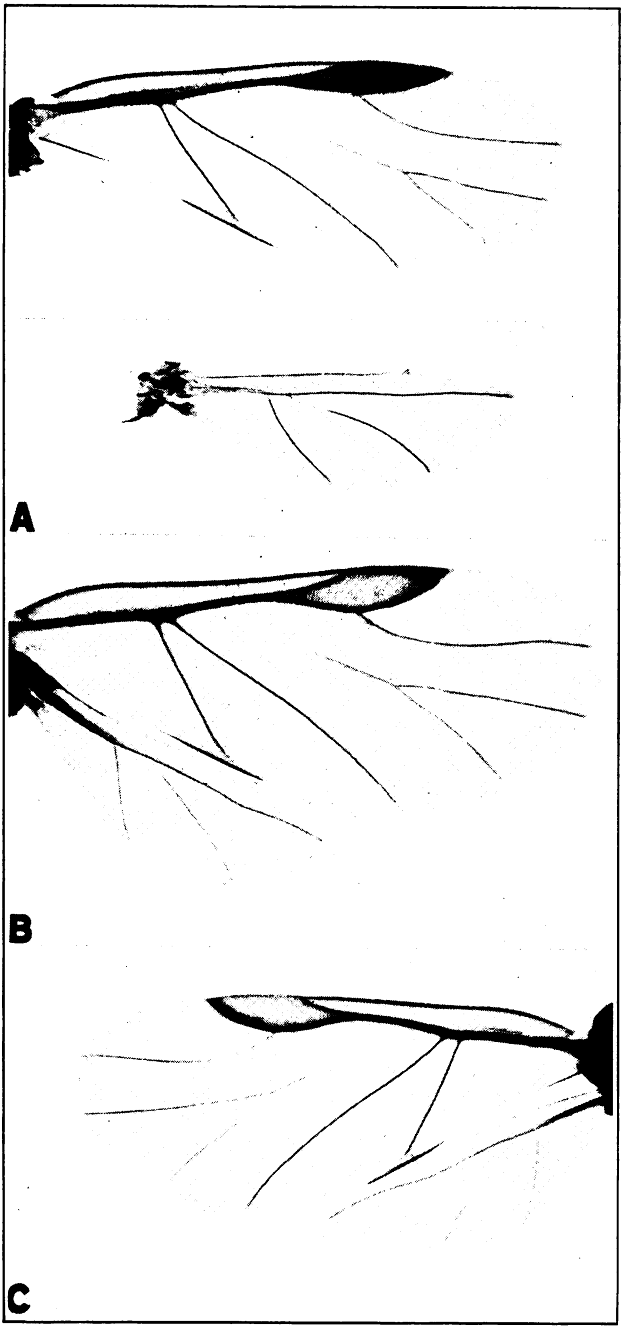

FIG. 142. A, *S. americana* in part, of authors. Wings of migrant from "roll" like Fig. 139 B. (68–13).

B, *S. lanigera* (*americana* in part of authors). Wings of spring migrant from elm "rosette" like Fig. 71 in Bulletin 217.

C, *S. lanigera* wings of fall migrant from mountain ash, *Pyrus* sp. (63–11).

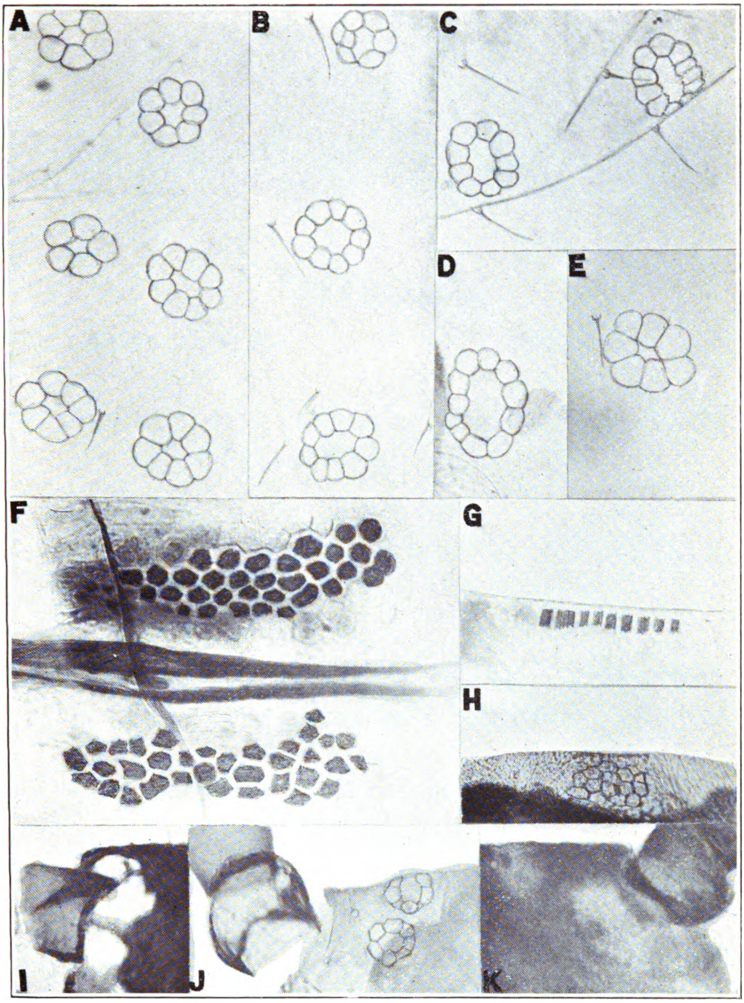

FIG. 143. Wax glands of *Schizoneura*. A–H, abdominal glands. I–K, head glands. A, *S. lanigera* (9–12) reared on apple from elm leaf progenitors. B and C, *S. rileyi*, pupal glands. D, *S. lanigera*, second generation from elm "rosette." E, *S. lanigera*, pupa from apple. F, *S. rileyi* stem female (52–13). G and H, *S. americana* in part. (20–13) wax glands of stem female from roll like Fig. 139 A. G, lateral aspect, H, dorsal aspect. I, same species as G and H stem female. J, *S. lanigera* second generation from "rosette." K, *S. lanigera* stem female from "rosette."

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BULLETIN No. 221 DECEMBER, 1913

CONSTANTS FOR NORMAL VARIATION IN THE FAT CONTENT OF MIXED MILK

(Pp. 299-305.)

A PEDIGREE SYSTEM FOR USE IN BREEDING GUINEA-PIGS AND RABBITS

(Pp. 306-313.)

ON THE ABILITY OF CHICKENS TO DIGEST SMALL PIECES OF ALUMINUM

(Pp. 314-318.)

CONTENTS.

The first paper in this bulletin presents definite measures of the degree to which the mixed milk from a large herd fluctuates from day to day in respect to its butter fat percentage and absolute fat content. The second paper describes a method of keeping pedigree records, adapted to mammals. The breeder of cattle, sheep or swine wishing to install a system of records will find this, with slight changes adapted to his needs. The last paper shows that no harm results to chicks which eat pieces of aluminum leg bands since the metal is slowly digested.

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BULLETIN 221.

I. CONSTANTS FOR NORMAL VARIATION IN THE FAT CONTENT OF MIXED MILK.[1]

By RAYMOND PEARL.

The fundamental variation constants of characters which are to be the object of genetic study are certainly highly desirable, if not absolutely necessary. On this account the constants to be presented here have been worked out, in connection with the studies of the inheritance of milk production now in progress in this laboratory. It is expected that from time to time further reports will be published recording normal variation constants for other elements of milk and of milk production.

The present paper deals with the variation in fat content, both absolute and relative, of the mixed or composite milk produced by a large herd of cows. It is, of course, a well known fact that the fat content of the milk of any individual cow fluctuates, within usually rather narrow limits, from day to day. Sometimes the range of such variation in the performance of a single cow may be very wide. An example of this has recently been furnished by Fraser[2] in which he cites the case of a cow on an official two-day test, where, within a period of 48 hours, the butter fat varied from 2.7 per cent to 6.7 per cent, and the absolute amount of butter fat from .08 to .9 of a pound.

The causes of such fluctuations in the fat content of the milk from an individual cow are various. Many of them belong in the general category of immediate environmental circumstances, including such things as kind and amount of food, weather conditions, etc. In addition there are undoubtedly many internal factors involved, such as, for example, the nervous condition of the cow, the general state of metabolism, etc.

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[1] Papers from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 57.

[2] Fraser, W. J. Variation in Milk Yield. Breeder's Gazette, Vol. LXIV, p. 562, 1913.

There is a widespread belief, which has indeed found its expresson in legislation, that in spite of the variation in the milk of the individual, if all the milk of the cows of a large herd be put together and thoroughly mixed, the resulting composite will not vary significantly from day to day in its fat content. It seems to be a matter of considerable importance, as a basic datum in milk production studies, to know the actual facts regarding the daily fluctuations in fat content of the mixed milk of a large herd.

The problem has recently been studied by Klose[3] for a herd of 70 cattle at the Milchwirtschaftliches Institut in Proskau. Only rather crude and inadequate statistical methods are used by Klose in the analysis of his data. Under these circumstances, and because of the valuable character of the raw data which are fully given in the paper, it has seemed desirable to apply biometric methods to these figures with a view to getting an accurate and trustworthy measure of the degree of variability shown. It is the purpose of this paper to present the results of such an analysis of Klose's data.

It may be said briefly that the records analyzed come from a herd of 70 animals (breeds not specified) and cover the milk of 30 consecutive days in each of four periods of the year. The cows were milked three times a day, morning, mid-day, and evening, and a separate record kept of the milk from each milking. The data include the following items; (a) The weight of milk produced at each milking, in kilograms: (b) the specific gravity of the milk; and (c) the fat percentage of milk. All of these figures are given for the three milkings of each day separately, and then for the total milk of the whole day. The four periods chosen for the records comprised practically the calendar months of March, May, July and October. The reason for choosing these particular months was to get the greatest possible contrast in regard to feeding and environmental conditions. During each of the months of March and July there was no change in the character of the food or the method of handling the animals. But in March the cows were in the barn (that is stall fed) all the time, whereas in July they were on pasture continuously. May and October represent months in which there were marked changes in the feed. In the course of the month of May the cows were put on pasture. In the month of October they were partly stall fed and partly on pasture, and other changes were made in the ration as well. In this way a contrast was afforded between the months of uniform feeding and months of varying feeding. The details as to the actual feed used may be found in the original paper.

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[3] Klose. Untersuchungen über die täglichen Schwankungen im spezifischen Gewicht und im Fettgehalt der Milch einer grösseren Herde. Milchw. Centralbl.-Milch-Zeitg. Jahrg. 42, pp. 385-392, 1913.

From the data described the constants of variation given in Table 1 and 2 of this paper have been calculated, under my direction, by Mr. John Rice Miner, the staff computer of this laboratory. The constants were calculated directly from the raw data without grouping. In one case, namely the evening milk during the month of May, it is evident that there are some errors in the records as printed in the original paper. Some of these are clearly typographical. Such we have been able to correct from internal evidence in the paper itself. Even after this partial correction, however, there are evidently still left some undetected errors, either in the original determinations of the fat percentages, or in the recording and printing of these. The variation shown in the milk of this milking in *per cent* of fat is so very much greater than that of any of the other data, that it can only mean some uncorrected error. In the case of the absolute amount of fat, the errors in per cent are apparently compensated for to a considerable degree (cf. Table 2). In the case of variation in fat per cent the variation constants for the evening milk of May are given first for the data exactly as they stand, and then for the data after correction of the obvious errors.

TABLE 1.

VARIATION CONSTANTS FOR FAT PERCENTAGE.

MONTH.	**Milking.**	**Mean.**	**Standard deviation.**	**Coefficient of variation**
March	**Morning**	2.717±.018	0.149±.013	5.487±.479
	Midday	3.210±.020	.166±.014	5.156±.450
	Evening	2.922±.015	.125±.011	4.295±.374
	Total day	2.916±.015	.126±.011	4.311±.376
May	**Morning**	2.772±.017	0.136±.012	4.899±.427
	Midday	3.215±.017	.138±.012	4.292±.374
	Evening (as given)	3.318±.038	.305±.027	9.195±.808
	Evening (partially corrected)	3.352±.030	.246±.021	7.354±.644
	Total day	3.031±.013	.103±.009	3.408±.297
July	**Morning**	3.092±.021	0.168±.015	5.415±.473
	Midday	3.162±.017	.135±.012	4.257±.371
	Evening	3.448±.024	.197±.017	5.722±.500
	Total day	3.196±.013	.104±.009	3.238±.282
October	**Morning**	3.305±.023	0.184±.016	5.573±.487
	Midday	3.570±.019	.156±.014	4.364±.381
	Evening	3.572±.021	.168±.015	4.695±.410
	Total day	3.445±.016	.131±.011	3.797±.331

TABLE 2.

VARIATION CONSTANTS FOR AMOUNT OF FAT.

MONTH.	Milking.	Mean.	Standard Deviation.	Coefficient of variation.
March	Morning	6.205±.069	0.560±.049	9.019±.792
	Midday	5.634±.108	.876±.076	15.548±1.387
	Evening	3.910±.092	.745±.065	19.059±1.719
	Total day	15.691±.210	1.701±.148	10.843±.995
May	Morning	8.159±.089	0.723±.063	8.859±.778
	Midday	6.592±.109	.883±.077	13.395±1.187
	Evening	4.810±.084	.680±.059	14.139±1.256
	Total day	19.494±.247	2.005±.175	10.287±.905
July	Morning	7.904±.098	0.797±.069	10.082±.887
	Midday	6.276±.073	.595±.052	9.481±.833
	Evening	5.034±.070	.568±.049	11.279±.995
	Total day	19.283±.217	1.761±.153	9.132±.802
October	Morning	8.286±.071	0.579±.050	6.990±.612
	Midday	5.958±.079	.644±.056	10.811±.953
	Evening	4.658±.092	.749±.065	16.080±1.436
	Total day	18.939±.197	1.602±.139	8.458±.742

From these tables the following points clearly appear:

1. In general the *percentage* content of fat is lowest in the morning milk. The fat percentage is higher in the other two

milkings of the day, and usually is highest in the evening milk, although the month of March forms an exception to this rule. That this diurnal change in percentage fat content is significant is shown by table 3, which compares the differences with their probable errors.

TABLE 3.

SHOWING THE DIFFERENCES BETWEEN MORNING AND EVENING MILK IN MEAN PERCENTAGE OF FAT.

Month.	Difference between mean fat percent of morning and evening milk.	Difference divided by its probable error.
March	.205±.023	8.9
May (as given)	.546±.042	13.0
May (partially corrected)	.580±.034	17.6
July	.353±.032	11.0
October	.267±.031	8.6

The probability that the percentage fat content of the evening milk is really higher than that of the morning milk is obviously so great as to amount to certainty for all practical purposes. This result agrees with the findings of Richmond.[4]

2. Without exception the *absolute* amount of fat is greatest in the morning milk, least in the evening milk, and intermediate in amount at the midday milking. This, of course, means that the amount of milk produced in the long interval between milkings is greater than in the short intervals. The differences are large and significant.

8. The difference between morning and evening milk in percentage fat content is significantly smaller in March and October, than in May and July. Owing to the uncertainty respecting the May evening milk constants stress cannot be laid on the very high difference in that month. July, however, shows the same relation, though to a less marked degree. It would on general grounds be expected that this difference would be greater on pasture than on the more exactly controlled stall feeding.

4. Taking into consideration the total day's milk it is seen that the *percentage* fat content rises steadily from March through October. The milk of this herd was a little over one-half of a per cent richer in fat in October than it was in March.

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[4] Cf. Analyst, Vol. 37, pp. 298-302, 1912.

This was not due to a progressively diminishing flow. The greater part of this increase in mean fat percentage occurred between July and October. This would indicate that pasture conditions (not necessarily feed alone) were a significant factor in producing the result.

5. The greatest *absolute* mean fat production per day was in May. There is, however, no significant difference in this respect between May, July and October. The influence of pasture conditions in stimulating the flow seems clear here.

6. Turning now to the variation constants, we note first that, contrary to common opinion, the *percentage* fat content of the mixed milk of a large herd exhibits a considerable variation from day to day. The standard deviations and coefficients of variation for this character in every case are more than 10 times as large as their probable errors. Certainly they cannot be considered insignificant.

7. The milk of this herd was most variable in percentage fat content in March and October and least variable in May and July. But none of the differences are significant in comparison with their probable errors. In general, it appears from these data that the degree or amount of daily *variation* in the percentage fat content of mixed milk is not significantly affected by such changes in feed and other conditions as are here involved.

8. The *absolute* amount of fat produced per day is roughly about twice as variable (compare coefficients of variation) relatively as is the percentage fat content of the milk. This result is of particular interest in relation to the rather widespread view that the variations in fat *percentage* of milk are to be accounted for in the main by fluctuations in the water content. It should be remembered that the result here set forth is for the *mixed* milk of a whole herd.

9. The relative variation in absolute fat produced, as measured by the coefficient, decreases steadily from March on through October. The amount of this decrease is, however, rather small, and in the extreme case is not certainly significant in comparison with its probable error.

10. There is no indication that the milk of any particular milking of the day is, either absolutely or relatively, significantly more variable in percentage fat content than the milk

of any other milking of the day. The total day's milk is, as would be expected, relatively somewhat less variable in fat percentage than the milk from any single milking.

11. In absolute amount of fat, the evening milk is relatively much more variable than the morning's milk. The midday milk occupies an intermediate position in this respect. This result would appear to indicate that during the night, when the cows are at rest, fat production in the udder is a more uniform process from cow to cow and from day to day, than during the day time when the cows are in some degree active.

While the foregoing constants and their discussion were obtained primarily for their significance in connection with further scientific studies, it is clear that they have some points of practical interest to the farmer selling milk to the creamery, to the creameryman buying milk, and to the dairy inspector enforcing a minimum fat content milk law.

II. A PEDIGREE SYSTEM FOR USE IN BREEDING GUINEA-PIGS AND RABBITS.[1]

By FRANK M. SURFACE.

For use in experimental breeding an adequate yet simple method of recording pedigrees is indispensable. Further, to one who has once used pedigreed material for physiological experiments the advantages of such material are very evident. In many of the delicate biological reactions for which small mammals are extensively used it is often clearly evident that all animals do not react alike. In many cases it can be supposed that such idiosyncrasies are a matter of heredity. Accurately pedigreed material will often aid in solving otherwise very puzzling results. On the other hand, experimental breeding is just beginning to recognize the heritability of physiological characters. The keeping of accurate records for a period of time will undoubtedly throw much light upon this phase of heredity.

With this two-fold object in view the writer recently devised a system of pedigree and other records for use with small mammals. These records have been in use for a number of months and their adequacy and simplicity have been clearly demonstrated. It seems not unlikely that a description of these methods may be of interest to investigators in several fields.

The chief requirements of any pedigree system are (1) accuracy, and (2) simplicity. This simplicity should include a minimum of operations in recording an animal and an easy accessibility to all the data for any individual. So far as my own experience goes, these requirements are best met by a system similar to that described some years ago by Dr. Pearl and myself[2] for use with poultry. Methods involving the same fundamental principles have also been described by Cole[3] for use in pigeon breeding.

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[1] Papers from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 58.

The experiments reported in this paper were carried out while the writer was connected with the Kentucky Agricultural Experiment Station.

MARKING THE ANIMALS.

The chief factor in establishing a reliable pedigree system is to mark the animals in such a way that there is no danger of mistaking them. About two years ago I corresponded with a number of breeders and laboratories using small mammals in an attempt to find what means were used for marking these animals. For physiological experiments it seemed to be almost universal to rely upon a description of color markings or in the case of solid color animals to mark them with spots of various anilin dyes. These together with cage records constitute the chief means of distinguishing the animals. A number of experimental breeders rely upon various combinations of punch marks in the ears to distinguish individuals.

None of these systems is satisfactory. Color markings, even conceding that two animals are not marked alike, require a considerable amount of time to compare the marks of the animal with the description. Any system of ear punches or anilin spots necessitates access to a key and again requires time and energy to decipher their meaning. Further, the combinations of punches and spots are quite limited so that it is very difficult to run a continuous series for any considerable number of individuals. Besides, dyes are not permanent and the ears are likely to be torn or pierced in fighting and so give trouble in reading the numbers.

Undoubtedly the most satisfactory method is to have a metal tag or band bearing a stamped number, in which case there can be no mistake, and the time and energy required in reading the record are reduced to a minimum. After a considerable number of experiments and many inquiries I obtained an ear tag made by T. Cadwallader at Salem, Ohio, for use with rabbits. Subsequent experiments have shown that this tag can be used very satisfactorily with guinea-pigs. A slightly different form might very well be adopted to use on even smaller mammals.

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[2] Pearl, Raymond, and Surface, F. M.—Appliances and Methods for Pedigree Poultry Breeding, Maine Agricultural Experiment Station, Bulletin No. 159, pp. 239-275. 1908, Cf., also Zeit. f. Biol. Tech. u Method Bd. 1, pp. 285-295, 1909.

[3] Cole, Leon J.—Methods of Keeping Pedigree Records in use at the Rhode Island Agricultural Experiment Station. Ann. Rpt. R. I. Exper. Station, 1908, pp. 317-324.

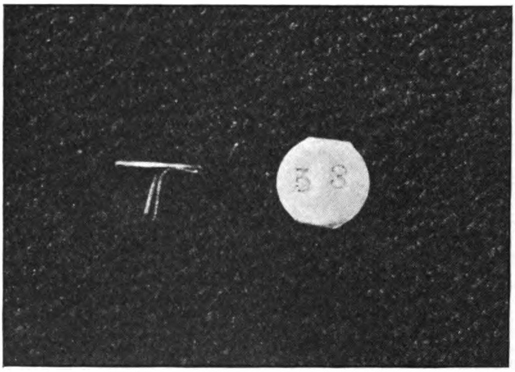


FIG. 144. Ear tags described in text.

The character of this tag is seen from figure 144. A small chick punch, such as can be obtained from any poultry supply house, is used to pierce the ear. The tag is then inserted and the points spread.

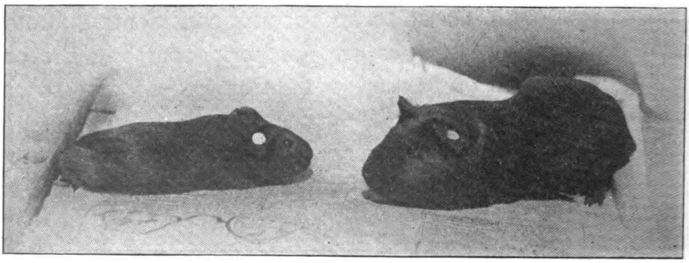


FIG. 145. Showing ear tags in place.

Figure 145 shows the ear tag in place on a young and an adult guinea pig. The tag does not inconvenience the animal in any way and if properly inserted they do not tear out. If desired the tags may be used in duplicate, one in either ear.

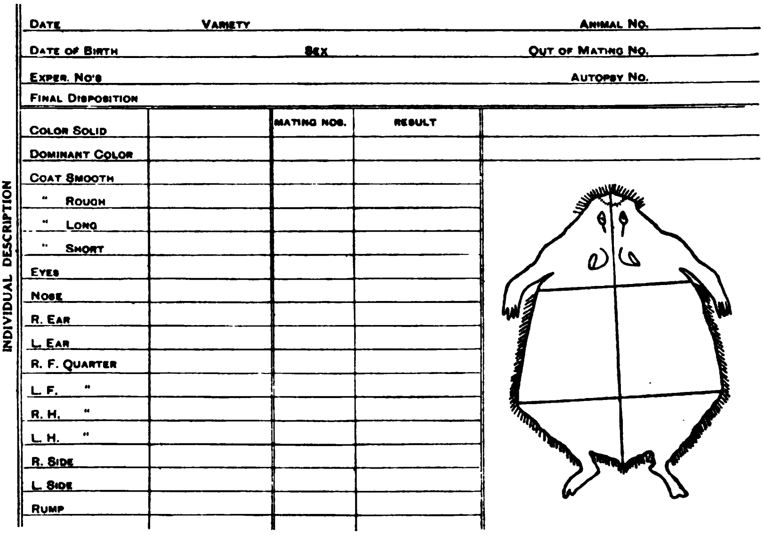
In our first experiment with this tag on guinea-pigs we made the mistake of putting it too close to the head and bending the points too far back. If these points are pressed too firmly against the skin they often cause a slight irrigation which may end in suppuration. In a few cases such tags were lost in the course of three or four months. However if the tag is placed just outside the heavy cartilage in the ear and the points are not pressed down too firmly we have never had any trouble of this kind. The difficulty would be entirely eliminated if the points of the tag were made a little longer.

The young guinea-pigs are so well developed at birth that they can be labeled at once without causing them any inconvenience. As a matter of fact, however, we find it more convenient to have the attendant place the pregnant females in separate cages a few days before parturition. He can then mark on the cage the date of birth and the number of young. About once a week we can then go through and label the young and make the necessary records. This involves but very little time and trouble. In the case of rabbits it is better to let the young get three or four weeks old before labeling them.

Since the principal object in growing guinea-pigs at the Kentucky Station was to furnish a sufficient supply for physiological and bacteriological work it was necessary to handle them by slightly different methods than are used by the experimental breeder. Most of the breeding is done in pens rather than in hutches. It has been found that better results are obtained if not more than 6 or 7 females are mated with one male. The pens are sub-divided by removable partitions into small areas about 2x4 feet. One male is kept in each of these pens and the females are placed in them, together with their young as soon as these latter have been tagged. When the young are about three weeks old they are removed to separate pens and the sexes separated. One pen contains surplus males which may be desirable for use in breeding. Two or more larger pens 4x4 feet), contain the surplus animals for experimental purposes. The sexes are separated, except that one male is placed in each pen of females so that if any females should remain long enough to bear young the pedigree system will remain intact.

PEDIGREE RECORDS.

For the pedigree records printed loose leaf sheets of uniform size (5x8 inches) were used. These sheets are made by the J. C. Moore Co., and are adapted to their type of binder. The sheets are readily removed or inserted when desired but at other times they are securely held in place. For the pedigree records proper, two forms are used. These are known respectively as the "Individual Description Record" and the "Mating Record."



INDIVIDUAL DESCRIPTION

DATE VARIETY ANIMAL NO.

DATE OF BIRTH SEX OUT OF MATING NO.

EXPER. NO'S AUTOPSY NO.

FINAL DISPOSITION

		MATING NOS.	RESULT
COLOR SOLID			
DOMINANT COLOR			
COAT SMOOTH			
" ROUGH			
" LONG			
" SHORT			
EYES			
NOSE			
R. EAR			
L. EAR			
R. F. QUARTER			
L. F. "			
R. H. "			
L. H. "			
R. SIDE			
L. SIDE			
RUMP			

FIG. 146. Description sheet for guinea-pigs.

Figure 146 shows, in facsimile, the individual description sheet used for guinea-pigs. At the top of this sheet are spaces for the date on which the description was made, the variety, if it is a pure bred animal, and the animal number which is the one on its ear tag. The date of birth, sex and the number of the mating from which it came are also given. Additional spaces are provided for the numbers of the experiments in which the animal may be used and for its autopsy number or final disposition if it does not come to autopsy.

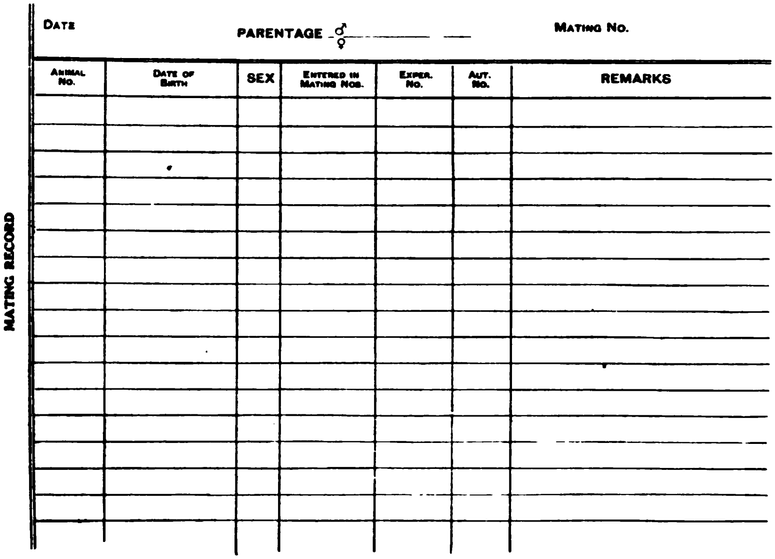
On the lower portion of the sheet there is, on the left, a list of coat and color characters which it is desired to record. On the right is a space for stamping the outline figure of a guinea pig. On this outline the limits of the principal color areas are marked. This is a great aid not only to the accuracy of description but also to the ease in referring to an animal's characters. Finally in the center of the sheet there are two columns in which are recorded the matings in which this animal enters and a brief summary of the results of each. This sheet thus provides a brief but relatively complete history of the individual.

If it is desired a record could be made of the number of the pen or hutch in which each animal is kept. This would often be a convenience in locating a particular individual. It involves the additional trouble of making a record every time an animal is transferred from one pen to another. So far we have not found this record necessary.

It should be said that the numbers are given the animals in a continuous series approximately in the order of their birth. The ear labels are purchased already numbered and for convenience in reference are used in consecutive order. No attempt is made to make the number show the pedigree. This is established through the "mating number" described below. The description sheets are arranged consecutively in the book. Thus if we should pick up guinea-pig number 124 we simply turn to page 124 and find the description and other data concerning this animal. The pedigree and breeding history of the individual are found by reference to the mating number from which it came and to the matings into which it enters as a parent.

MATING RECORD.

The key to this pedigree system is the "mating number." Every time a particular male and female are placed together an arbitrary number is given to that mating. These mating numbers are assigned in a continuous series in the order in which the matings are made. The "mating number" in itself is no indication of the pedigree but is simply an index by which the pedigree can be determined. Printed sheets similar to those described above are used for the mating records. A facsimile of one of these sheets is shown in figure 147.



MATING RECORD

Date

PARENTAGE ♂ ♀

Mating No.

Animal No.	Date of Birth	SEX	Entered in Mating Nos.	Exper. No.	Aut. No.	REMARKS

FIG. 147. Mating record sheet.

At the top of this sheet there is space for the date on which the mating was made; a record of the individual numbers of the male and female entering into this mating and the mating number. Below are spaces for recording each offspring. The number, date of birth and sex of each offspring are entered at the time the young animal is given its ear tag. Spaces are also provided for giving references to its subsequent history.

Guinea-pigs have from one to four or more young in a litter. If the same mating is continued we stamp below the number of the last offspring the date at which the female was again placed with the male and the subsequent litter is recorded below. If the female is mated with another male this mating receives a new number and is recorded on another page. All the mating numbers of any individual are recorded on its description sheet.

Still born or aborted offspring are recorded with the date and sex but are not given individual numbers.

The mating sheets are arranged in the binder in consecutive order so that if we are referred to mating number 79 we can at once turn to this page.

INDICES.

The above two record sheets are all that are necessary in this pedigree system. However it is convenient to have at least one index. This is an index to the matings into which any animal has entered. For this the numbers of the animals are stamped in consecutive order in alternate columns on loose leaf sheets. When any animal is mated the number of this mating is entered opposite the number of the animal. Thus we can see at once all the matings into which an animal has entered without having to look up its individual description sheet.

For some purposes it is also convenient to have an index showing the mating *from* which each individual arose. Neither of these indices is necessary for the completeness of the record.

The operation of this pedigree system may be illustrated by an example. Thus we may pick up the guinea-pig bearing the number 231 on its ear tag and we wish to know its family and breeding record. We first turn to page 231 of the individual description book. This gives the animal's description, sex, date of birth, etc. The description can be verified, if we wish, by glancing at the marks on the outline figure (cf. fig. 146). This page also shows that this animal came from mating number 81 and that it has entered twice in mating number 114 and once in mating number 147. On page 81 of the mating book are given the numbers of the parents of this individual as well as its full brothers and sisters. The more remote ancestors may be traced through the parent numbers. On pages 114 and 147 of the mating book will be found all the offspring of this individual as well as the numbers of the individuals with which it was mated. If any of these offspring have been mated, such mating numbers will appear in the proper columns on these pages. In this way the grandchildren and more remote offspring can be traced at once. Reference to the experiment number and autopsy number makes the record complete at every point.

The operations in describing and recording an individual are relatively simple. Several cross references must be made but this involves but little time. The indices mentioned above aid in the ease with which this can be done.

III. ON THE ABILITY OF CHICKENS TO DIGEST SMALL PIECES OF ALUMINUM.[1]

By MAYNIE R. CURTIS.

It is a matter of common observation that chicks will peck at, and sometimes swallow, small pieces of bright metal. If these have sharp points or corners, they may puncture the wall of the alimentary tract allowing the escape of some of the contents into the body cavity, and may thus indirectly cause peritonitis.

Among the several cases of peritonitis in the Maine Agricultural Experiment Station flock in the last five years four have been observed where at autopsy a sharp metal article was found still protruding from the puncture it had made in the gizzard wall. The articles were a small nail, a tack, a pin and a piece of steel watch spring. In these cases it was the sharpness of the metal which caused the difficulty. However, on account of the interposition of the gizzard a bird is less able to pass out a large indigestible article than is an animal which masticates its food. Such an article which is too large to pass through must either remain in the gizzard or must be ground up or dissolved by the digestive fluids.

The purpose of the present note is to record some observations on the fate of certain pieces of metal which when swallowed by chickens cause no disturbance in their physiological processes. The pieces of metal were aluminum leg bands. They were practically pure aluminum showing only the slightest trace of iron.[2]

---

[1] Papers from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 59.

[2] It is a pleasure to acknowledge my indebtedness to Prof. James M. Bartlett, Chemist of the Maine Agricultural Experiment Station, for the analysis on which this statement is based.

When chicks are taken from the pedigree incubator baskets at this Station each one is banded with an aluminum band. This is a flat strip of metal with rounded corners which is bent into a ring around the chick's leg. As the bird grows this ring is enlarged from time to time, but when the chick is six to eight weeks old it has outgrown this band altogether and is then rebanded with another type of aluminum band. This second band is adjustable. The portion of the band not used is snipped off. The size of these snips varies greatly with the size of the chickens' legs. As the chicks are rebanded the discarded bands and snips are dropped on the range. It is not unusual to see chickens pecking at them. Figure 148 shows at the top a random sample of fifteen snips cut from the second bands and at the bottom two of the discarded first bands. The one of these to the left is opened out flat and the one to the right is bent double. It may be seen from this figure that the snips are narrower than the bands.

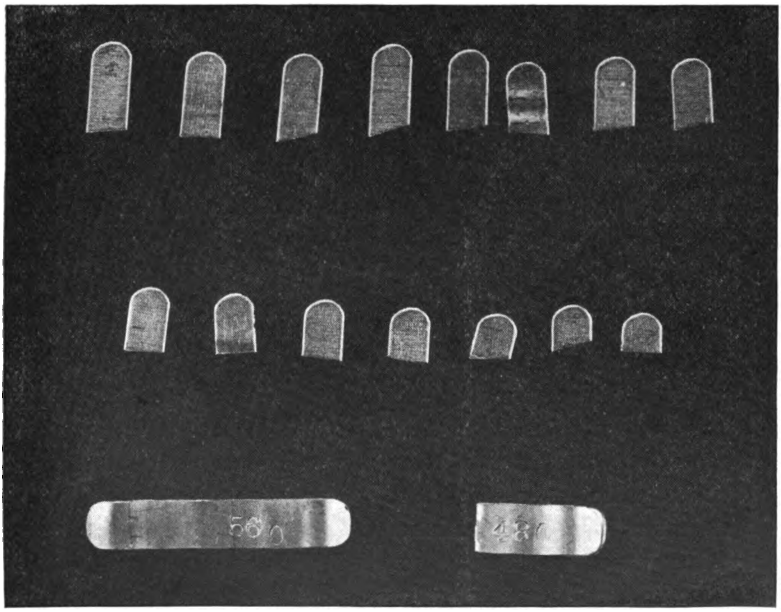


Fig. 148. Shownig band snips and whole chick bands.

August 6, 1913, a fine strong Barred Plymouth Rock pullet, normal in all respects, was killed for material. In the gizzard contents of this bird a bright glimmer of metal was noticed. The whole gizzard contents were then examined and found to contain fourteen aluminum leg bands or pieces of leg bands. A photograph of these is shown in Figure 149. They are in varying stages of dissolution and it is not possible to tell accurately how many bands the bird had swallowed, as it is probable that in some cases two or more of the pieces are from the same band. Some of the fragments are undoubtedly snips. The number swallowed may be conservatively estimated as four bands and six snips. One band is still all together but is nearly separated at one point. Other pieces are very small and thin. Some have holes through them. The dissolution has evidently been accomplished by a combination of the mechanical grinding of the gizzard and the action of the hydrochloric acid of the gastric juice. The outer surfaces of the bands are covered with fine scratches while the inner surfaces show fewer scratches and more evidence of solution. After careful cleaning this entire collection of bands weighed 0.857 grams. The mean

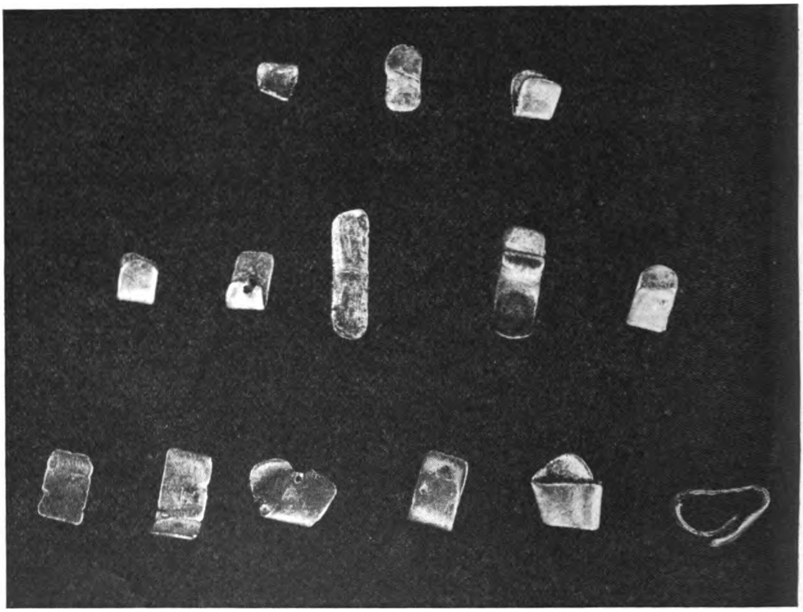


FIG. 149. Partly digested bands and snips from gizzard of B. P. R. ♀.

weight of one band as it comes from a chick's leg is 0.2545 grams. The mean weight of a snip (calculated from the fifteen snips shown in Figure 148) is .0421 grams. The weight of five bands and six snips would be approximately 1.2706 grams. The difference between this and 0.957 or 0.3136 would be a rough estimate of the loss due to the digestion of the metal. This is a loss of 24.69 per cent.

This case shows that a chick may pick up a considerable quantity of aluminum and use it somewhat as it does grit, gradually wearing and dissolving it away until it becomes small enough to pass out with the feces. Aluminum is soluble in dilute hydrochloric acid. A leg band placed in a .5 per cent solution shows hydrogen bubbles on the surface, although the action is not very rapid. Further the aluminum salt formed (aluminum chloride) is non-poisonous. If the metal swallowed were not attacked by the gastric juice it would still be worn away by the grinding action. On the other hand if it were attacked and the resulting salt were poisonous (as for example zinc chloride) the result might be death from poisoning.

Two further questions suggested themselves. One was: how long had it taken the bands to reach their present state of decomposition? Secondly: was the swallowing of the bands a personal idiosyncrasy of this individual bird?

There are, of course, no data on the time the bird began to swallow bands but the rebanding of the chicks in that yard was begun the first of June or about nine weeks before the bird was killed. Therefore, some of the bands may have been in the gizzard for that length of time, but not longer.

Since the observation of the above case the gizzard contents of six other normal, healthy birds of approximately the same age as this bird running on the same range have been examined. Five of these contained no leg bands. One contained the bands and parts of bands and snips shown in Figure 150.

There are probably fewer bands and more snips in this case than in the other but the process of dissolution has evidently advanced farther and it is even more difficult to tell how many there are. The number swallowed is estimated as one band and ten snips. The weight of these at the time of swallowing would have been 0.6755 grams. Their weight after removal from the gizzard was .301 grams. That is, the loss was .3745 grams or 55.44 per cent.

It thus seems evident that birds possess a considerable individuality in regard to the tendency to swallow pieces of bright metal, since with equal opportunity only two of the seven birds examined had swallowed leg bands. However, in a careful search of the yards where the rebanding had been completed several weeks before, a single snip and very few first bands were found. While it is possible that some of them were completely buried in the dirt, the soil in these yards is very hard and it is probable that most of them had been eaten by the chicks.

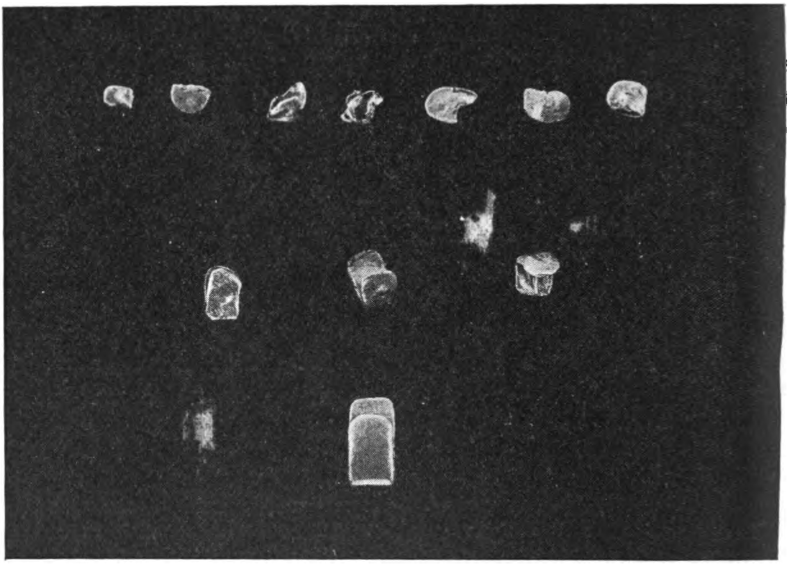


FIG. 150. Leg bands and snips from gizzard of B. P. R. ♀.

GIFT
MAY 18 1914

[Bulletins 209 to 222 constitute the Report for 1913. In binding, pages i-xx at the end of this bulletin should be detached and placed before Bulletin 209, which begins with page 1]

Maine Agricultural Experiment Station

BULLETIN No. 222. **DECEMBER, 1913.**

FINANCES, METEOROLOGY, INDEX.

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BULLETIN 222.

METEOROLOGICAL OBSERVATIONS.

For many years the meteorological apparatus was located in the Experiment Station building and the observations were made by members of the Station Staff. June 1, 1911, the meteorological apparatus was removed to Wingate Hall and the observations are in charge of Mr. James S. Stevens, professor of physics in the University of Maine.

The instruments used were at Lat. 44° 54′ 2″ N. Lon. 64° 40′ 5″ W. Elevation 135 feet.

The instruments used are the same as those used in preceding years, and include: Wet and dry bulk thermometers; maximum and minimum thermometers; rain-gauge; self-recording anemometer; vane; and barometer. The observations at Orono now form an almost unbroken record of forty-five years.

METEOROLOGICAL SUMMARY FOR 1913.

OBSERVATIONS MADE AT THE UNIVERSITY OF MAINE.

1913.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Not stated.	Total.
Highest temperature	58	51	65	85	79	87	91	93	90	77	66	51	......	......
Lowest temperature	-5	-19	-7	9	26	34	48	34	29	29	9	-11	......	......
Mean temperature	27.0	16.1	33.5	44.7	50.1	61.3	67.9	65.2	56.8	54.2	40.5	28.1	45.45	......
Mean temperature in 45 years	16.51	18.72	28.50	40.97	52.88	62.08	67.21	65.27	57.53	45.54	34.60	21.97	42.57	......
Total precipitation in inches	2.81	1.66	4.42	3.54	3.55	1.38	5.86	3.15	4.42	7.35	3.39	2.87	......	44.00
Mean precipitation in 45 years	4.06	3.75	4.22	2.91	3.57	3.40	3.34	3.45	3.50	3.87	3.60	3.68	......	43.33
Number of days with precipitation of .01 or more	8	4	15	11	8	8	15	7	9	16	6	5	......	112
Snow fall in inches	1.25	14.0	9	......	......	......	......	......	......	......	......	10	......	34.3
Mean snow fall in 45 years	22.0	21.5	15.6	5.3	0.19	......	......	......	......	0.72	7.1	16.3	......	90.4
Number of clear days	5	12	6	10	8	15	7	14	17	6	15	11	......	126
Number of fair days	8	6	8	5	10	10	12	10	7	6	8	9	......	99
Number of cloudy days	18	10	17	15	13	5	12	7	6	19	7	11	......	140
Total movement of wind in miles	5320	4802	6212	4698	4091	4289	4255	3542	3087	4416	4364	3408	4374	52484

REPORT OF TREASURER FOR FISCAL YEAR ENDING JUNE 30, 1913.

RECEIPTS.	Hatch fund.	Adams fund.	General account.	Inspections.
Balance July 1, 1911				*$6,993 98
Treasurer of United States	$15,000 00	$15,000 00		
State				9,000 00
Sales, etc			11,410 95	
Analysis fees				13,039 24
Total	$15,000 00	$15,000 00	$11,410 95	$29,033 22
DISBURSEMENTS.				
Salaries	$5,149 81	$11,551 27	$1,418 35	$13,664 48
Labor	3,663 41	130 71	2,475 09	
Publications	72 32			
Postage and stationery	497 65	48 75	106 99	665 23
Freight and express	317 82	153 72	836 39	143 65
Heat, light and power	271 81	181 04	247 10	241 81
Chemical supplies	185 33	4 22	5 61	637 06
Seeds, plants and sundry supplies	736 14	491 15	1,667 27	64 78
Fertilizers	918 03		12 90	
Feeding stuffs	1,352 53	817 43	182 74	
Library	739 91	82 27	78 78	
Tools, implements and machinery	502 12	187 39	58 53	
Furniture and fixtures	91 68	40	60 50	396 17
Scientific apparatus	3 00	512 84		123 04
Live stock	98 27	97 00	617 10	
Traveling expenses	212 99	463 16	81 13	2,632 87
Contingent expenses			91 72	79 47
Buildings	187 18	278 65	1,312 99	2,843 98
Deficit June 30, 1912			673 88	
Balance June 30, 1913			1,483 88	*7,540 68
Total	$15,000 00	$15,000 00	$11,410 95	$29,033 22

* The large balance is due to the fact that fees are paid in advance for the whole year and the State year ends December 31.

The classified report does not include $1,000.00 paid for services and feeding stuffs in poultry investigations by the U. S. Department of Agriculture, an appropriation of $4,500 from the State for printing Station publications, nor $863.25 expended for Animal Husbandry investigations in anticipation of the receipt of the appropriation from the State.

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